2020 FINAL OPERATIONS REPORT

NDCMP

NORTH DAKOTA CLOUD MODIFICATION PROJECT

NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD

WEATHER MODIFICATION INTERNATIONAL

weathermodification.com

NORTH DAKOTA CLOUD MODIFICATION PROJECT

2020 FINAL OPERATIONS REPORT

Report prepared for

NORTH Dakota Be Legendary.™ | Atmospheric Resource Board WATER COMMISSION

State of North Dakota
Atmospheric Resource Board
State Water Commission
900 E Boulevard Ave
Bismarck, ND 58505

by

WEATHER MODIFICATION INTERNATIONAL

Weather Modification LLC
3802 20th Street North
Fargo, ND 58102
Phone 701.235.5500
Fax 701.235.9717

weathermodification.com

OCTOBER 2020

Cover Credits (Top to Bottom): (1) Tyler Couch, (2) Alex Bestul, (3) Tyler Couch, (4) Alex Bestul, (5) Alex Bestul, and (6) Jacob Berg.

EXECUTIVE SUMMARY

This report details the activities of Weather Modification International (WMI) during the 2020 North Dakota Cloud Modification Project (NDCMP) field operations. This was the 60th consecutive summer season of the NDCMP and the second of a three-year contract with WMI and the NDCMP. WMI provided six specially modified aircraft, cloud seeding equipment, pilots, aircraft maintenance, aircraft tracking and telemetry systems, intern co-pilot training, and communications equipment in the NDARB radar offices.

District I included Bowman County and southern Slope County (Hume, Carroll, Cash, Connor, Sheets, Mineral Springs, and Cedar Creek Townships). Two aircraft were based in Bowman, both capable of conducting cloud base-seeding operations (Piper Seneca II).

Fig. 1. NDCMP 2020 Operational Target Areas. The circles indicate approximate radar coverage from District I- Bowman (blue) and District II-Stanley (orange). Forecast services (pink) were provided from Bismarck, ND. Graphic by WMI.

District II operated in McKenzie, Mountrail, and Williams counties with three project aircraft. Two were equipped for base seeding operations (Piper Seneca II) and stationed in Watford City and Stanley, respectively, with a top-seeding aircraft (Beechcraft King Air C90) based in Williston. A "hybrid" C340A aircraft was stationed in Dickinson to act as a support aircraft for both districts. Able to perform base- and top-seeding operations, implementation was dependent on meteorological conditions and specific project/district needs. A total of 64.56 seeding flight hours (does not include time for reconnaissance and reposition missions) was conducted by the hybrid aircraft this season within the two districts, with 28.53 flight hours in District I and 36.03 flight hours in District II.

Operations were conducted on a 24-hour per day, 7-day per week basis. The project period ran from June 1st through August 31st, 2020 for both Districts. The six project aircraft flew a total of 479.05 hours (154.04 hours in District I and 325.01 hours in District II). Together 102.9 kilograms of silver iodide and 3,314.87 pounds of dry ice pellets were dispensed during the 2020 season.

Fig. 2. Seed 1 (N39655) preparing to takeoff from the Bowman, ND airport for a seeding mission over District I on June 21st, 2020. Photo by ARB Intern Meteorologist Nate Woltmann.

An anomalously wet fall transitioned to a much drier spring over the 2019-2020 winter months, which resulted in a timely planting season. Semiarid conditions continued through the summer, though well-timed bursts of convective activity kept crops flourishing. These precipitation events were balanced between both districts and favored the earlier summer months, as climatology would expect. With an active June, nearly half of the base-seeding flight hours were used by month's end. Flight hours for the other available aircraft were utilized less due to visibility limitations, and the time required between launch and active seeding.

Drought conditions crept in slowly mid-summer as occasional mid-level impulses were not enough to keep the ground sufficiently moist. Furthermore, precipitation in July and August was hindered as a strong mid- to upper-level ridge settled over the Midwest. As a result, rain enhancement efforts were uninterrupted until crops matured and harvest began.

All counties within the project area conducted hail suppression operations from June 1st – August 31st, with suspensions occurring for rain enhancement as the summer entered late July (see Table 1, below). Many precipitation events through July were marginal convective systems, which lead to an imbalance between flight hours used and precipitation accumulated. Deep moisture and sufficient upper-level organization allowed for hail-criteria convection in both districts, often producing strong supercells or potent mesoscale convective complexes. District I regularly saw organized supercells, while District II more frequently saw mesoscale convective complexes and low-level jet induced nocturnal convection.

2020 NDCMP RAIN ENHANCEMENT SUSPENSION TABLE

DISTRICT I	*DISTRICT II*
Bowman/Slope suspended from 7/27 - 8/31 (end project)	Williams suspended from 7/20 – 8/31
	Mountrail suspended from 7/27 – 8/31
	McKenzie suspended from 7/30 – 8/31

Table 1. 2020 NDCMP Rain Enhancement Operations Suspension Table.

The late summer synoptic setup was seasonally typical, but remained drier than average. A large amplified ridge established itself over the western US, which resulted in long stretches without appreciable precipitation in the project area. This compounded by a suspension of rain enhancement efforts, lead to a quiet August with few operations. Neither district opted for a project extension; the NDCMP season finished as scheduled on August 31st, 2020.

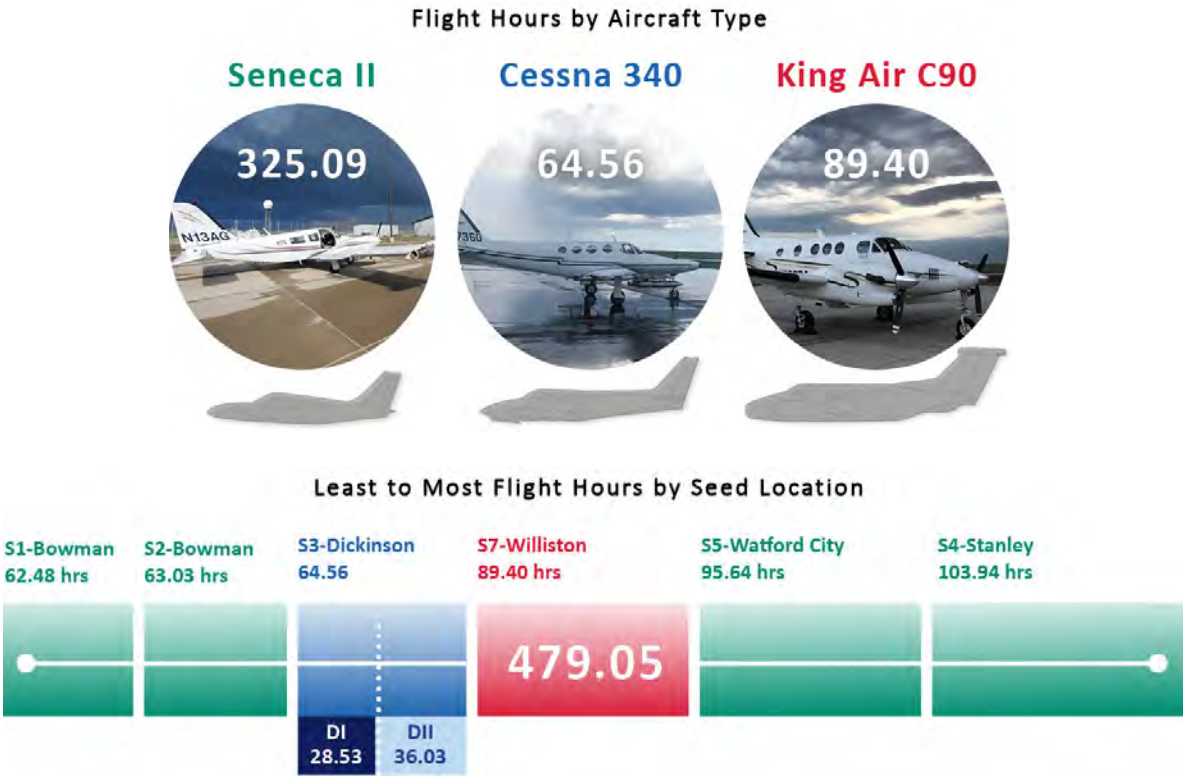

Fig. 3. 2020 NDCMP flight operations categorized by aircraft type and location, including the most to least flight hours by location. Seneca II aircraft are represented in green, the C340A in blue, and the King Air C90 in red.

The 2020 season ended with a total of 479.05 flight hours, considerably lower than all calculated statistical averages, including the 20-year average of 564.68hrs, the 15-year average of 539.75hrs, the 10-year average of 531.59hrs, and the 5-year average of 497.85hrs. A decrease in flight hours in the last five years can be partially attributed to the loss of Burke County in 2019 and Ward County this season.

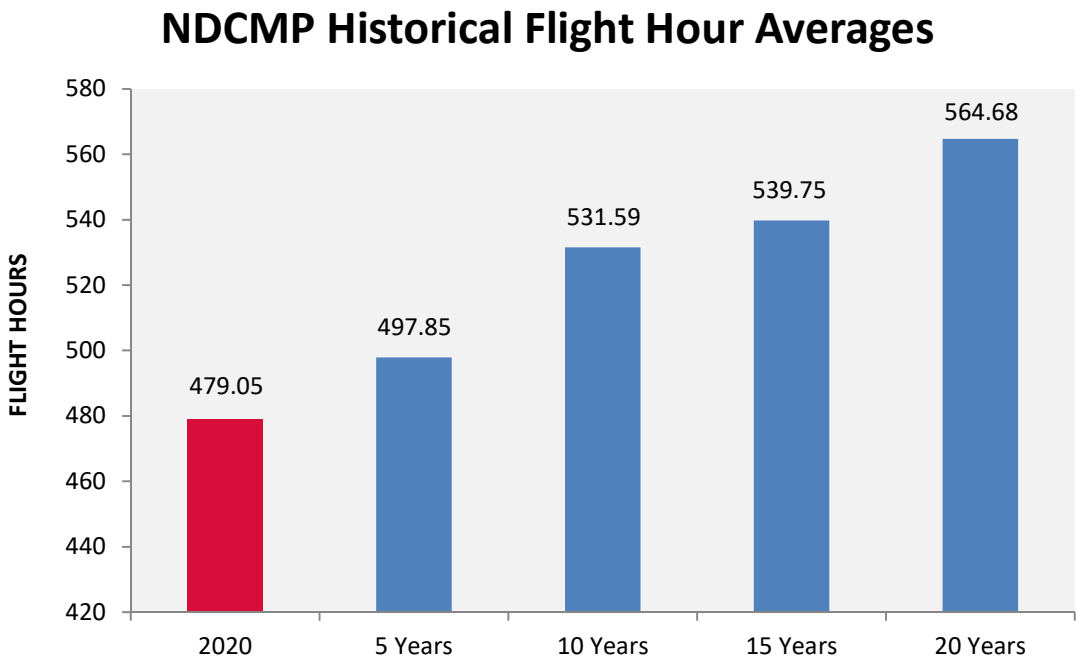

Fig. 4. Flight hour historical average displayed in 5-year increments starting in 2000, inclusive of 2020.

The 2020 NDCMP season started amidst the Novel Coronavirus Disease (COVID-19) global pandemic that was declared on March 11th, 2020 by the World Health Organization. This impacted the program in a variety of ways, including:

- Intern rotations through Williston for top-seeding experience were not scheduled. Instead, one intern was assigned to Williston for the summer with the only exception being the state-mandated 10-day vacation period.
- WMI and the ARB deployed special policies and materials to all bases and aircraft for the purpose of sanitation.
- Public visitation to the radar sites was cancelled.
- ARB staff district tours were reduced and restricted to only necessary personnel.
- The University of North Dakota pilot internship program was cancelled by the University; however, the State of North Dakota was able to continue the program by hiring the interns directly.
- Crews were encouraged to maintain social distancing practices both during missions and during downtime between storms.
- All WMI team members were expected to follow WMI's COVID-19 plan.
- The NDCMP field team as a whole implemented the ND Smart Restart Plan.

The NDCMP team was flexible and we thank them for their professionalism and dedication to continuing safe operations during this time of uncertainty.

Fig. 5. The 2020 NDCMP crew participates in a virtual ground school for the first time in the project history. Ground school traditionally is held the last week of May in-person at the ARB offices in Bismarck, ND. Left to right, top to bottom – Alex Sailsbury, Kelli Schroeder, Dan Brothers, Corey Clay, Jacob Berg, Mark Schneider, Darin Langerud, Benjamin Stoinski, Harrison Rademacher, Jordan Provost, Michael Steinke, Charles Sassaman, Cody Kleinsteuber, Cade Kissinger, Tyler Couch pictured in front of Kelsey Carrabre (left) and Maria Cole (right), Damien Gehler, Jody Fischer, Kyle Peterson, Ryan Starkey, and Taylor Exizidis-Meier. Screenshot by WMI Captain Alex Sailsbury.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

North Dakota farmers have historically faced above-average crop losses due to hail and drought; these challenges have contributed to reduced crop yields and farm incomes. This led to the search for ways to manage these conditions, which could consequently improve the average North Dakotan's quality of life. One promising new technology was the emerging science of weather modification. The first cloud seeding activities of record in North Dakota occurred in 1951, performed by farmers using ground based generators.

In 1961, the founders of Weather Modification International began using aircraft for a program to suppress hail in an initial target area of 540 square miles, in the central area of what is now District I. This area has had an active program in some form each year since, with the exception of 1990 when District I did not participate in cloud seeding operations due to budget constraints.

Operations to the north (currently referred to as District II) started one year later and have remained active in various counties every year since. However, this year marked the first time in 61 seasons that some form of cloud seeding did not occur in Ward County. A third district, including Benson, Nelson, and Griggs Counties, operated from 1974 through the 1981 season. In the mid 1970's, there were as many as 17 counties in North Dakota participating in the cloud seeding program. The number has decreased due to various factors over the years, but currently there are 5 active counties in target areas that cover 8,370 square miles (or, almost 5.4 million acres) – almost 12% of the state's area.

In 1965 and 1969, legislation was passed in North Dakota enabling counties and townships to levy two mills for funding of cloud seeding projects. The source of funds was this 2 mill levy, by township elections under NDCC Chapter 58-03-07, or by voluntary funding. The Program was primarily implemented by emphasizing hail reduction. Rain enhancement operations provided added economic benefits to those counties which had an Authority. Counties or associations of counties pooled resources to finance their local programs. The North Dakota Legislature established the North Dakota Weather Modification Board (NDWMB), later renamed the Atmospheric Resource Board (ARB) in the 1975 legislative session. The State Legislature further provided an appropriation for the remainder of the biennium to implement the 1976 operational program on a cost-sharing basis.

Fig. 6. WMI aircraft await a NDCMP season on the ramp in Bowman, ND. Image taken by Hans Ahlness, summer of 1984.

The cloud seeding projects before the creation of the NDWMB had been paid for by voluntary contributions and county appropriations. The 1976 operational program included 50% state matching funds equaling the county appropriations in support of the project in their area. These matched county funds were used specifically for field operational costs. As state matching fund levels dropped through the mid-1980's, many counties dropped out of the program. State funds were also used for research and evaluation, although some federal funds supported UND-trained co-pilots and evaluation data underwritten by the Bureau of Reclamation.

With the loss of Ward County this year the project eliminated the Seneca II aircraft from Kenmare. The Dickinson based-aircraft continued to be shared by both districts with District II paying 65% and District I paying 35% of the aircraft costs.

The recently concluded 2020 program was the 46th consecutive season under the Board's direction. The North Dakota Atmospheric Resource Board is comprised of seven members appointed by the Governor of North Dakota. Each member represents a geographic district and serves a four-year term. Weather modification authorities within the districts establish possible candidates through nomination. Ex-officio members also serve on the board.

2020 NDCMP BOARD MEMBERS (*Denotes Chair, **Vice Chair, *** Secretary)

DISTRICT I	Monte Hininger***	Williston, ND
DISTRICT 2	Vacant as of 6/10/2020	
DISTRICT 3	Rep. David Monson	Osnabrock, ND
DISTRICT 4	Chris Theisen	Thompson, ND
DISTRICT 5	Casey Veil**	Jamestown, ND
DISTRICT 6	Tom Tupa*	Bismarck, ND
DISTRICT 7	Thomas Burke	Bowman, ND
EX-OFFICO MEMBERS		
John Paczkowski, P.E.	ND State Water Commission	
Kyle Wanner	ND Aeronautics Commission	
Angela Seligman	ND Department of Environmental Quality	

Table 2. 2020 NDCMP Board Members.

2020 NDCMP COUNTY AUTHORITY MEMBERS (*Denotes Chair)

DISTRICT I	
BOWMAN COUNTY	*SEVERE WEATHER MANAGEMENT ASSOC.*
Wayne Mrnak, Bowman*	Robb Narum, Bowman*
Wes Andrews, Bowman	Ryan Brooks, Bowman
Bobb Brewer, Bowman	Dan Powell, Bowman
Dean Pearson (Treasurer), Bowman	Wayne Wegner, Bowman
Wade Schaaf, Bowman	

Table 3. 2020 NDCMP County Authority Members – District I.

2020 NDCMP COUNTY AUTHORITY MEMBERS (*Denotes Chair)

DISTRICT II		
MCKENZIE COUNTY	*WILLIAMS COUNTY*	*MOUNTRAIL COUNTY*
Eldean Flynn, Cartwright*	Jeff Knox, Ray*	Aaron Skarsgard, Stanley*
Gary Levang, Keene	John Hovde, Epping	Lynn Heinle, White Earth
Luke Taylor, Watford City	Keith Overland, Williston	Tim Johnson, Stanley
Rodney Cross, Alexander	Cierra Aamodt, Williston	Hayley Jung, Stanley
Roger Flatland, Watford City	Paul Weyrauch, Ray	*Vacant*

Table 4. 2020 NDCMP County Authority Members – District II.

2 NORTH DAKOTA ECONOMIC IMPACT

A study in 2019 from the NDSU Department of Agribusiness and Applied Economics investigated the impact that the NDCMP has on the state's economy. An update of a 2009 analysis, the study considered the value of hail suppression and enhanced rainfall during the growing season. Using the harvested acreage of the top eight crops plus alfalfa, the study combined crop insurance data, production statistics, and NDCMP results to estimate the added value of the project for both the actual target areas and the benefits if the project was statewide. Rain enhancement was figured at two levels, a 5% and a 10% increase (covering the range of results from long-term evaluations of the NDCMP), and combined with a 45% hail reduction estimates to derive the results.

Fig. 7. WMI Captain (Seed 3) Jacob Berg captures the local farmers near Watford City, ND beginning to harvest their crops underneath clear skies on August 15th, 2019.

In the NDCMP seeded counties, the direct economic value of cloud seeding specifically to enhance rainfall was estimated to range from $9.19 to $18.15 per planted acre, or $21.2-41.9 million in direct benefits to agriculture production. The hail suppression addition adds another $3.0 per planted acre, or $6.9 million annually. Compared to the cost of the project, those figures would give a benefit-to-cost ratio of 31-to-1 up to 53-to-1, an excellent return on investment. This shows the huge benefit that the NDCMP can provide.

Enhanced agricultural production can affect other areas of North Dakota's economy. Increased crop yields can potentially increase tax revenue between $576,000 – $999,000 annually. Most significantly, this study does not include the considerable benefits that a reduction in hail damage has to property, especially in more populated areas. A copy of the complete report and other NDCMP program evaluations are available on the North Dakota State Water Commission website at: http://www.swc.nd.gov/arb. On the navigation panel, click on ND Cloud Modification Project and then Program Evaluations.

Counting ARB staff, ARB Board of Directors, the participating County Weather Modification Boards, Slope County Severe Weather Management Association members, and applicable WMI and FJC staff, there were over 100 people directly associated with some facet of the 2020 NDCMP. This does not include the local vendors and technicians employed by the ARB and WMI during the season.

3 2020 AIRCRAFT CONTRACTOR

Weather Modification International is a global atmospheric sciences company committed to continued advances in the field of weather modification. With over 60 years of successful operations, WMI has pioneered safe and effective techniques for cloud seeding. These advances have made it possible to conduct operations 24 hours per day, seven days a week. These techniques – many formulated in North Dakota operations – have allowed WMI to provide aircraft, seeding and research equipment, radars, personnel, and company expertise in the areas of cloud physics research and atmospheric sampling for various governmental agencies and private entities around the world.

WMI was originally formed in 1961 in Bowman, North Dakota, and the anti-hail program begun at that time was the genesis of the current NDCMP. WMI relocated to Fargo, ND in 1993 and a sibling company, Fargo Jet Center LLC (FJC) was incorporated in 1994. Since then, WMI has grown exponentially. Today, WMI facilities in Fargo have more than tripled in size and employees with FJC number more than 180 personnel worldwide. FJC adds a wide range of aviation services including a charter flight department, aircraft refueling services, an FAA approved aircraft maintenance and overhaul facility, avionics shop, aircraft rental and a flight school.

FJC also operates Premier Jet Center, a full service FBO/repair station, paint and upholstery shop, and Exclusive Aircraft Sales based in Eden Prairie, MN. The operating companies frequently share resources, skills, talents, and equipment – each contributes to the success of the other. The synergy realized from several multi-faceted operating companies highlights a strong aviation enterprise that continues to grow.

Fig. 8. Weather Modification Int'l and Fargo Jet Center LLC headquarters at Hector International Airport, Fargo, ND.

4 PROJECT DESIGN

The design of the 2020 North Dakota Cloud Modification Project was based on techniques developed and refined over years of operational programs. These techniques, many developed here in North Dakota, were used in conjunction with seeding criteria evolved by compatible research programs and the comprehensive North Dakota Cloud Modification Project Operations Manual, March 1993, latest revision May 2015. A companion manual, the NDCMP Radar Applications Manual (latest revision May 2012) provides guidance for the project meteorology staff.

As set forth by the NDARB, the project design is a "non-randomized, development and operational program for the purposes of decreasing hail damage, increasing seasonal rainfall, and achieving certain development objectives for improved operations". In summary, the project design is one in which any cloud that meets the criteria for increasing rainfall or decreasing hail is seeded (within the limits of equipment and personnel) rather than clouds being chosen on a random basis for seeding. In theory, any project member can initiate seeding operations, but in practice the ARB radar meteorologists usually direct when and where the WMI pilots operate.

Fig. 9. WMI Captain Alex Bestul (Seed 2) conducts a cloud-based seeding mission over Bowman County with both generators active on July 30th, 2020. Photo by WMI Captain Alex Bestul.

5 OPERATIONAL AREAS

North Dakota weather modification activities were conducted in two operational target areas, or Districts. District I included Bowman County, as well as Hume, Carroll, Cash, Connor, Sheets, Mineral Springs, and Cedar Creek Townships in Slope County. District II encompassed Williams, McKenzie, and Mountrail counties.

This was the first year since the program's inception that Ward County did not conduct any type of cloud seeding operations. On June 9th, 2020, Ward County held a county-wide vote on the continued participation in the North Dakota Cloud Modification Project. The official results were 1,891 for continuation, and 10,908 against continuation, representing a total vote count of 12,799, about 19% of the population of Ward County. As a result, Ward County discontinued its participation in the project. This changed the landscape of District II for the second season in a row. In 2019, Burke County opted out and removed its funding of the project after a four-year trial participation period.

District I remained without "buffer zones" for the 2020 season, a change adopted ahead of the 2018 season.

Fig. 10. A representation of the seeding target areas for both districts, aircraft bases, and radar range capabilities for the 2020 NDCMP. Graphic courtesy of the NDARB.

5.1 WMI Aircraft Base Locations

Aircraft bases are determined by the ARB in cooperation with WMI and the county weather modification authorities. Airports are chosen using location, runway length, fuel availability, and facilities as factors. The top-seeding and hybrid aircraft need access to instrument approaches to fully utilize their capabilities. Housing availability for the crews is also important.

Two Piper Seneca II aircraft (US FAA registration N33144, later replaced with N13AG and N39655) were based in Bowman, ND for District I operations. The three District II aircraft were based at Stanley (Seneca II, N9798C), Watford City (Seneca II, N121WA), and Williston (King Air C90, N709EA). The shared "hybrid" aircraft for both districts was based in Dickinson (Cessna C340A, N37360).

5.2 NDARB Weather Radar Sites

Two Enterprise Electronics Corporation WSR-74C 5-cm weather radars, both owned by the NDARB, were employed on the project. These radars are surplus and upgraded National Weather Service units, purchased and moved to the project sites. One unit each is located at the Bowman and Stanley airports.

Fig. 11. The sun sets behind the Stanley radar site during the 2020 NDCMP season. Photo by WMI Captain Taylor Exizidis-Meier.

6 DAILY OPERATIONS

The 2020 season of the North Dakota Cloud Modification Project became active at noon local time on June 1st for both districts. The project ended for both districts at 11:59 pm local time on August 31st, 2020.

Specialized project forecasts were prepared each morning by ARB staff in Bismarck and were based on National Weather Service data, the UND Weather and Research Forecasting (WRF) model, regional synoptic observations and satellite information. The meteorologists in the field offices received the daily forecast either online or by joining, if available, a video conference hosted by the Bismarck Intern Meteorologist at approximately 12:00 noon, CDT. In the event of significant changes, updates were furnished to the radar meteorologists by phone and on the website.

Radar meteorologists and pilots all kept an eye out for significant weather activity. Sometimes with input from the aircraft crews, the ARB radar meteorologists launched aircraft for seeding missions. Cloud candidates for seeding were usually chosen by the radar meteorologists, with the pilots making the final determinations based upon storm inflow, cloud structures, flight safety, and other factors.

Fig. 12. The Seed 2 (N13AG) crew refuel and rechem after a mission in Bowman, ND on July 31st, 2020. Photo by WMI Captain Alex Bestul.

7 AIRCRAFT

WMI uses well-equipped, twin-engine aircraft, for all flight operations. In addition to their high performance characteristics, in comparison to smaller, single-engine aircraft, the twin-engine aircraft provide an extra measure of safety in bad weather, in-cloud, and nighttime operations. All of the seeding aircraft are owned and modified by WMI.

Fig. 13. Seed 3 (N37360, Cessna 340A) and Seed (N39655, Seneca II) on the ramp in Bowman, ND on July 30th, 2020. Photo by ARB Intern Meteorologist Nate Woltmann.

WMI operated four Piper Seneca II (PA34-200T) aircraft for cloud-base seeding (Fig. 15), one hybrid Cessna 340A (Fig. 14, 16) aircraft that was capable of both base and top seeding, and one Beechcraft King Air C90 (Fig. 17). WMI's Piper PA34-200T Seneca II aircraft are turbocharged, twin 200-horsepower engine light aircraft, while WMI's Cessna 340A's are turbocharged, twin 310-horsepower engine aircraft with pressurized cabins. The Beechcraft King Air C90 aircraft was used for cloud-top seeding, though it was also equipped with wing flare racks for cloud-base operations if needed. The WMI King Air C90 has two 550hp turboprop engines with a pressurized cabin.

WMI operates C340A and C90 aircraft on projects around the world. Besides North Dakota, WMI operates multiple King Air C90's and C340A aircraft on projects in Canada and multiple King Air C90's and B200's in California, Idaho, and Wyoming during the winter. Beechcraft King Air Series aircraft have become the desired platform for cloud seeding and atmospheric research industry wide due to their reliability, payload, and maintenance availability both domestically and internationally.

Aircraft must be flown and maintained in accordance with US Federal Aviation Administration (FAA) rules and regulations. WMI's specially modified cloud seeding aircraft, when fitted with seeding equipment, must be operated in RESTRICTED category – meaning that their operations are limited to the special purpose operations for which the equipment installations are certified by the FAA and are bound by extra rules that prohibit these aircraft from carrying passengers who are not part of the project, among other things.

All aircraft must also be inspected and maintained according to approved schedules; the Seneca's and C340A's used on this project must all have a yearly "annual" inspection and certain required maintenance checks at each 50 and 100 hours of operation. The turboprop C90 must be operated under a progressive inspection program, and has mandatory 200-hr and yearly inspections. WMI seeding aircraft are equipped for flight in icing conditions should the need arise. In addition to normal aircraft and seeding systems, aircraft furnished for the project were equipped and certified for instrument flight rules (IFR) with GPS navigation equipment.

Fig. 14. Seed 3 (N37360) captured with distant thunderstorms in the background on July 16th, 2019. Photo by WMI Captain Tyler Couch.

Prior to the 2020 season, all WMI project aircraft underwent renewed annual inspections (as required by the FAA) and had the appropriate WMI seeding equipment mounted to conform to the project contract requirements. Project pilots assisted WMI and FJC mechanics in Fargo to prepare the aircraft. This provides the pilots with valuable training and hands-on experience with seeding equipment and their particular aircraft. All seeding generators were flight tested with acetone before delivery to ensure proper operation.

The project aircraft were ferried to their respective summer bases prior to the start of project. Senecas N33144, N39655, N121WA, and N9798C were delivered on May 29th, 2020 to Bowman, Watford City, and Stanley respectively. C340A N37360 and King Air N709EA were also delivered to their individual bases Dickinson and Williston on May 29th, 2020. On June 1st, 2020 Seneca N13AG replaced N33144 in Bowman. Crews ensured all aircraft were fully loaded with burn-in-place (BIP) and ejectable (EJ, on applicable aircraft) pyrotechnics, and silver iodide solution prior to the start of project at noon local time on June 1st. Crews conducted "District Tour" flights before the start of the 2020 NDCMP to familiarize themselves with their area of operations, function of the acetone burners, and reliability of the voice and data links with their respective controlling radar sites.

7.1 Aircraft Maintenance

All pre-season, major aircraft, and seeding equipment maintenance was performed at the Weather Modification International/Fargo Jet Center facilities in Fargo, ND. Jody Fischer, Director of Flight Operations, and Kirk Hamilton, Chief Pilot, tracked and supervised the required maintenance and support for the aircraft during the summer. The pilot-in-command (PIC) of each aircraft was instructed to call Hamilton immediately if any unscheduled maintenance was required.

With the 24/7 nature of WMI's commitments for the ARB, when an aircraft has a maintenance problem it needs to be repaired quickly. WMI has developed a working relationship with two maintenance shops during the past seasons: (1) Bottom Line Aviation LLC in Bowman, (2) Watford AeroService LLC in Watford City, and (3) Western Edge Aviation LLC in Dickinson. These relationships allow WMI to have inspections and limited maintenance performed on-site, which reduces the down time of the aircraft by eliminating travel time to and from Fargo. WMI provided these locations with parts, documentation, and support services. If local shops are unable to perform any maintenance tasks, WMI can fly a mechanic and or parts to the broken project aircraft or ferry it to Fargo for more extensive work. WMI has always attempted to have smaller items taken care of by local maintenance shops in western ND when possible.

Additional aircraft maintenance outside of routine and/or scheduled inspections occurs yearly, with the 2020 NDCMP featuring:

- On June 1st 2020, Seed 2 (N33144) discovered a crack in the exhaust system on the right engine. Hamilton ferried N13AG to Bowman to replace N33144. No flight operations were missed.
- On June 2nd, Seed 2 (N13AG) discovered the nose gear tire was flat upon pre-flight. Hamilton flew a Fargo Jet Center mechanic to Bowman to replace the tire. No flight operations were missed.
- On June 23rd, Seed 2 (N13AG) flew to Fargo for routine maintenance. The decision was made to return N33144 to Fargo and keep N13AG in the field as Seed 2 for the summer. Both crews returned to Bowman that day with no flight operations missed.
- On June 23rd, Seed 3 (N37360) flew to Fargo for an oil filter examination. No flight operations were missed.

- On June 29th, Seed 3 (N37360) had a vacuum pump failure. It was replaced on July 1st in Fargo. No flight operations were missed.
- July 7th, Seed 4 (N9798C) experienced an issue with their datalogger (onboard telemetry computer). A WMI electronics technician determined the parts needed to rectify the problem and shipped them next-day service. The aircraft proceeded to Watford City for routine scheduled maintenance on July 9th early in the morning. Before the maintenance technician could complete the inspection, he had a family emergency. The aircraft and crew spent the night in Watford City. The next day the inspection was completed and they returned to Stanley where they also repaired the datalogger. No flight operations were missed.
- July 12th, Seed 4 (N9798C) experienced a second datalogger malfunction. A WMI electronics technician assisted the crew with the repair over the phone with the spare parts sent on July 8th. A test flight was performed to verify proper operation of the datalogger. No flight operations were missed.
- On August 10th, Seed 7 (N709EA) flew to Fargo to have broken light lenses replaced. They flew back to Williston on August 11th. No flight operations were missed.

If any of the project aircraft needed maintenance that would have it removed from service for an extended period, WMI always had spare C340A and Seneca II seeding aircraft on standby to assure uninterrupted service. While a spare aircraft is not required by contract, WMI has the resources to provide this service in case of an emergency.

7.2 WMI Aircraft Telemetry System and Communications - *AirLink*

The NDARB contracted with WMI to provide the project radars with equipment to track each seeding aircraft's position, altitude and seeding events. Each aircraft was equipped with a WMI "datalogger" system composed of a purpose-built computer running WMI's ADAS (Aircraft Data Acquisition System) software. The computer receives inputs from the aircraft's GPS receiver, ice nuclei generators, and the firing systems from the BIP and belly mounted ejectable flare racks. All project aircraft were equipped with a datalogger as part of the telemetry systems that provided position and altitude information as well as seeding events. The datalogger systems were designed and are specially built by WMI in Fargo.

The WMI ADAS system logs position from the aircraft GPS (latitude, longitude, altitude, and groundspeed) during the entire flight at a data rate of once per second. The computer also records the time and location of seeding events. A telemetry radio in each aircraft transmits the ADAS information to the WMI *AirLink* computer in the radar. This information is then sent to the radar's TITAN computer to generate the aircraft tracks on the TITAN display (see Fig. 21). Files are created on the aircraft computer's USB flash drive for later analysis. The NDARB was provided with the *AirLink* computer software to replay the flight track data for post-flight analysis. The data was downloaded from each aircraft on a regular basis, checked by WMI, and sent to the ARB at the end of the season.

AirLink is able to provide, in real-time, a display of the seeding aircraft flight paths generated from aircraft GPS data. *AirLink* displays position information, seeding status, and atmospheric microphysical information (if the aircraft is equipped with probes), all transmitted via radio modem from each seeding aircraft to a receiver in the radar. The event tracking capability allows the radar meteorologists to determine which thunderstorm complexes were seeded and the number of flares used. If chosen by the radar operator, files can also be created on the ground computers in the radars to enable playback of flight tracks for post-mission analysis.

WMI supplied multi-channel VHF (Very High Frequency) aviation-band communications base station radios that were used at each radar field office for communications in association with *AirLink* with the seeding aircraft. WMI also supplied antennae and low-loss cabling at each site for good reception, and power supplies for the radios that ensured adequate transmitting power. The NDARB maintains the appropriate FCC radio station licenses for the radar sites.

8 CLOUD SEEDING EQUIPMENT

WMI designs, manufactures, and operates a wide variety of cloud seeding equipment. Each PIC received pre-season operation and maintenance training on the seeding equipment. WMI maintains an extensive inventory of seeding equipment spares that was restocked as needed during the project. WMI also keeps an inventory of spares for the airplanes used on the project to avoid downtime waiting for parts.

Each WMI Seneca II aircraft was outfitted with the following equipment:

- 2 WMI-Lohse ram-air pressurized liquid-fueled AgI generators, with a 7-gallon usable capacity, calibrated to a flow rate of 3.0 gallons per hour at 120 mph airspeed.
- 2 Wing-mounted flare racks, each capable of carrying 12-16 burn-in-place flares.

Fig. 15. WMI seeding Piper Seneca II aircraft. Photos by Keisuke Yoshimura (2013 ARB Intern Pilot), Kirk Hamilton (2017 Seed 1 Captain) and Steffany Royal (2017 Seed 2 Captain).

The WMI Cessna 340A aircraft was outfitted with the following equipment:

- 2 WMI-Lohse ram-air pressurized liquid-fueled AgI generators, with a 7-gallon usable capacity, calibrated to a flow rate of 4.0 gallons per hour at 130 kts airspeed.
- 2 Wing-mounted flare racks, each capable of carrying 12 burn-in-place flares.
- 2 Belly-mounted ejectable flare racks, 204 flare capacity total.

Fig. 16. A WMI C340A seeding aircraft. Photos courtesy of Kirk Hamilton (2019 Seed 7 Captain), Artie Cifarelli (2017 Seed 9 Captain) and WMI.

The WMI King Air C90 aircraft was outfitted with the following equipment:

- 2 Wing-mounted flare racks, each capable of carrying 24 burn-in-place flares.
- 1 Dry ice dispenser, capable of holding 200 lbs of dry ice pellets.
- 3 Belly-mounted ejectable flare racks, 306 flare capacity total.

Fig. 17. WMI cloud top Beechcraft King Air C90 aircraft N709EA, Seed 7, in Williston. Photos courtesy of Kirk Hamilton (2019 Seed 7 Captain), Tristan Brecht (2019 ARB Intern Pilot), and WMI.

8.1 Seeding Equipment Performance

The generator performance is a measure of the total time that one seeding generator was inoperative during hail missions, when two were required. The following graph depicts an accurate illustration of the percentage that the project aircraft were operating at less than desired capability. This year a new record low burner-failure rate was recorded at 0.83%. This is far lower than the 10-year average of 2.54%, and a significant improvement from last season.

The record low burner-failure rate this season can be attributed to the retention of experienced pilots on project, as well as increased training before project on burner maintenance and troubleshooting. Prior to the season, WMI Captain Alex Sailsbury revised and expanded the Lohse Burner Manual with updated graphics and text to make the manual more in-depth and streamlined. This significantly contributed to the lower burner-failure rate. Thank you Alex!

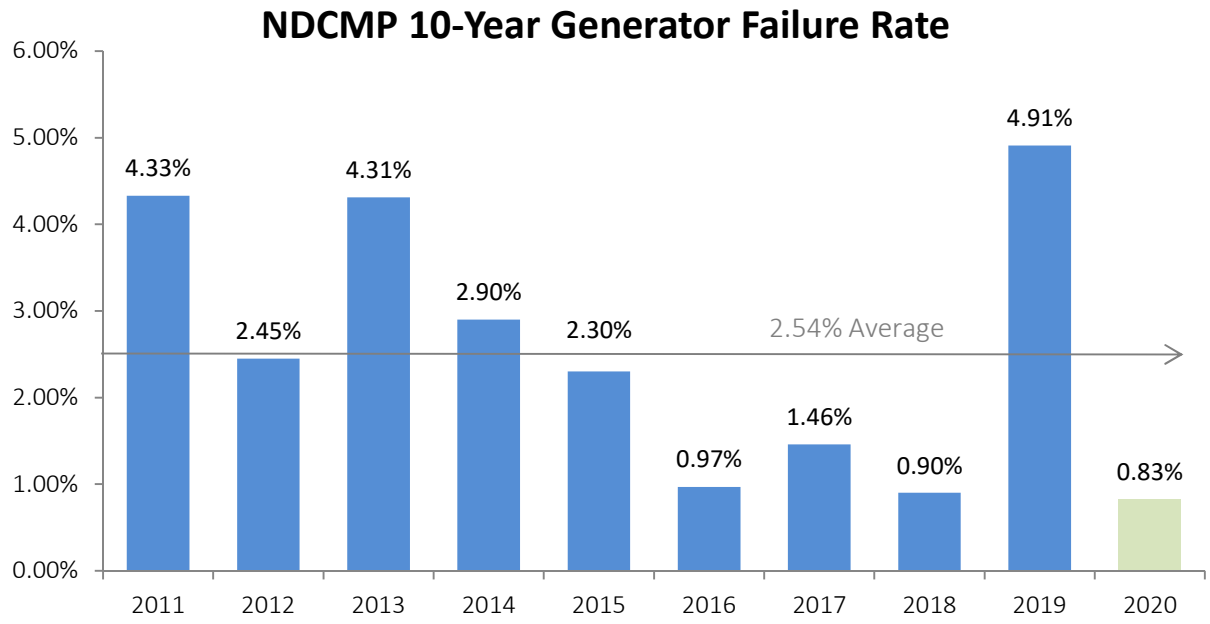

Fig. 18. NDCMP 10-Year Generator Failure Rate chart.

Fig. 19. ARB Intern Pilot Kelsey Carrabre conducts maintenance on one of the ice nuclei generators at the beginning of the season. Photo by ARB Intern Meteorologist Nate Woltmann.

All of the seeding materials used during the project were supplied by the ARB. These included dry ice pellets, silver iodide pyrotechnics (20 gram ejectable (ICE-EJ™) and 75 gram burn-in-place (ICE-BIP ™) flares), and a silver iodide solution. This solution's mixture contains silver iodide, ammonium iodide, paradichloro-benzene, and sodium perchlorate, all dissolved in acetone.

Seeding formulations have evolved with research and experience, and now incorporate ingredients that make the formulas faster acting – better for hail suppression operations, where the crews are often working with fast-growing storms. The seeding solution was mixed at each site by the field crews. The NDARB provided secure storage for the seeding materials at each airport.

Fig 20. Jordan Provost, ARB Intern Pilot, mixes seeding solution at the Williston, ND base. Photo by WMI Captain Alex Sailsbury.

9 WEATHER RADAR SYSTEMS

The NDARB operates two five-centimeter EEC WSR-74C radars, located at the Bowman and Stanley airports. Both radars have been upgraded to Doppler, providing meteorologists in the field with velocity data to forecast rapid storm development from outflow boundaries and to help avoid directing aircraft into areas of turbulence from microbursts. The Doppler upgrade also improves the sensitivity of the radars, allowing them to detect early echoes, which aids in the response time for rain enhancement missions. Another upgrade that is useful for both radar sites is the remote access capabilities, which allow the radar technician or anyone at the NDARB to monitor the radars remotely and fix any software problems.

Each radar set has an antenna pedestal and a dish. The antenna pedestal is the elevation-over-azimuth type. The dish is parabolic, 8 ft. (2.4 m) in diameter, constructed of aluminum and installed within a 12 ft. (3.7 m) diameter fiberglass radome, which protects the radar from wind, precipitation, and hail damage and allows it to operate continuously. The antenna assembly is positioned on a steel tower at the Bowman Airport and atop the radar building in Stanley, at an adequate height to provide the best possible radar coverage for the target areas.

Fig. 21. Nate Woltmann, ARB Intern Meteorologist, captures a distant thunderstorm and the Bowman radar at the airport on June 19th, 2020. Seeding operations occurred later in the day.

The data collected by the radar are analyzed through an IRIS/TITAN system. The Interactive Radar Information System (IRIS, a Sigmet/Vaisala product) and the Thunderstorm Identification, Tracking, Analysis, and Nowcasting (TITAN) system developed by scientists from the National Center for Atmospheric Research (NCAR) are software/hardware systems provided to each radar site by NDARB. A clone of the software setup is also kept in Bismarck for remote data analysis.

IRIS is very useful for meteorologists in that it provides the real-time display of the radar data. Along with displaying the reflectivity detected at each elevation angle in real-time, IRIS also has tools available to do cross sections on the most recently completed scan data (cannot do cross sections on real-time display data). IRIS is not as useful when directing aircraft, since it does not display aircraft and their position. IRIS is a great tool to use to determine if a storm is increasing or decreasing in intensity, and it is a good backup tool for cross sections if the TITAN machine is inoperable.

While IRIS is useful, the TITAN system is the main software used when running operations. The TITAN system provides 16 levels of contoured color radar reflectivity data, zooming capabilities, custom target overlays, instant playback, and real-time aircraft flight track/seeding event superimposition. TITAN software runs on a LINUX operating system, and the TITAN system displays constant altitude plan position indicator (CAPPI), vertical storm cross section, storm history, storm time-height profile and reflectivity distribution. The history of storm motions (yellow circles) and forecast storm motions (red circles) are also displayed. A CAPPI display can be selected for various altitudes starting at 2 kilometers above the surface and stepping up in 1 kilometer increments. It is also possible to create a “composite PPI” display, which plots the strongest radar reflectivity at any altitude in a PPI (radar display) format. A zoom function allows the radar operator to zoom-in on interesting features, such as hail cores, on the display. The vertical cross section capability enables a radar operator to produce a two dimensional slice through a thunderstorm. Unlike conventional radar Range Height Indicators (RHI), the vertical cross section option permits cross sections to be made along any two points on a PPI display and not just along the azimuth from the radar.

Aircraft flight tracks can be superimposed upon the TITAN display, and the field offices and project aircraft have the equipment to do so (see the previous section describing the WMI datalogger system). Superimposed flight tracks aid the radar meteorologists in directing the cloud seeding aircraft to the most suitable seeding candidates (see Fig. 23). An electronic overlay generated by a computer file displays the project target area as well as county boundaries and prominent cities and geographical features.

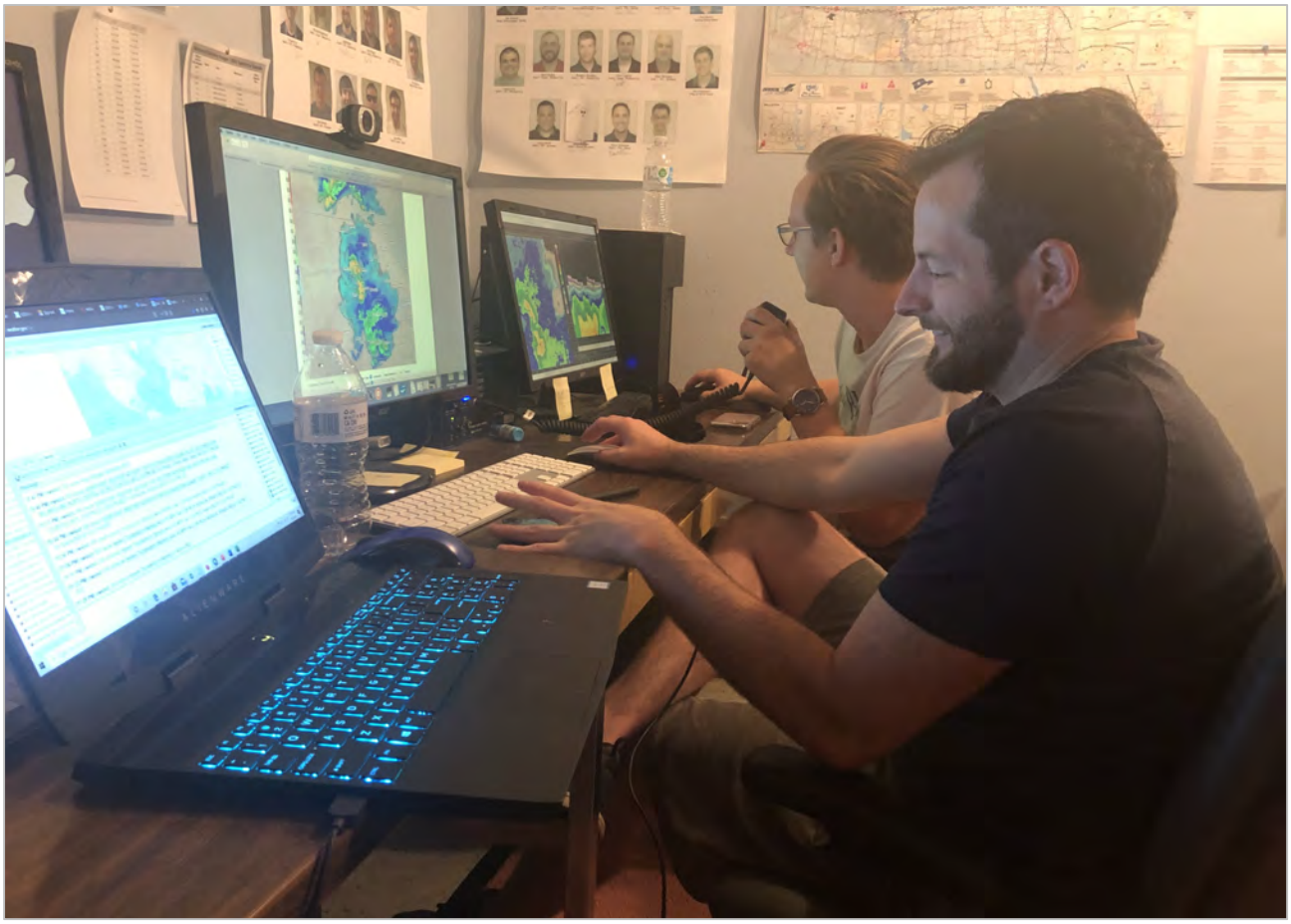

Fig. 22. District II Meteorologists Corey Clay and Charles Sassaman communicate with pilots during a seeding mission on July 3rd, 2020. Photo by WMI Captain Jacob Berg.

Radar maps and flight track data are saved automatically in approximately 5-minute increments. The time period required to complete a volume scan varies dependent upon the RPM setting of the radar. The large volume of graphical data being recorded and stored is the reason for the necessity of upgrading to a specialized computer. The weather radar data is recorded onto hard-drive disks for storage and playback at a later time, and the storms can be replayed for future analysis. The composite PPI radar maps are automatically sent to the ARB website when a scan has been completed providing access to recently recorded data. The links (accessible from the ND State Water Commission website, http://www.swc.nd.gov/arb) can be viewed using any PC with an internet server, and show current radar maps displaying reflectivity data and aircraft flight tracks. Using additional funding from surrounding counties in the offseason the Bowman radar operates year-round, while the Stanley radar is only used during the project season.

Implemented in 2018, online "seeding tracking" remained operational for the 2020 season. Airplane tracks depicted when airplanes were seeding in addition to when they were flying. GPS tracks showed individual colors when airplanes were flying but not seeding, and turned gold when aircraft were seeding. The only exception was when displaying "ejectable flares", which were denoted by an asterisk. GPS flight tracking of airplanes on the North Dakota Cloud Modification Project has been provided on project radar images since 2004.

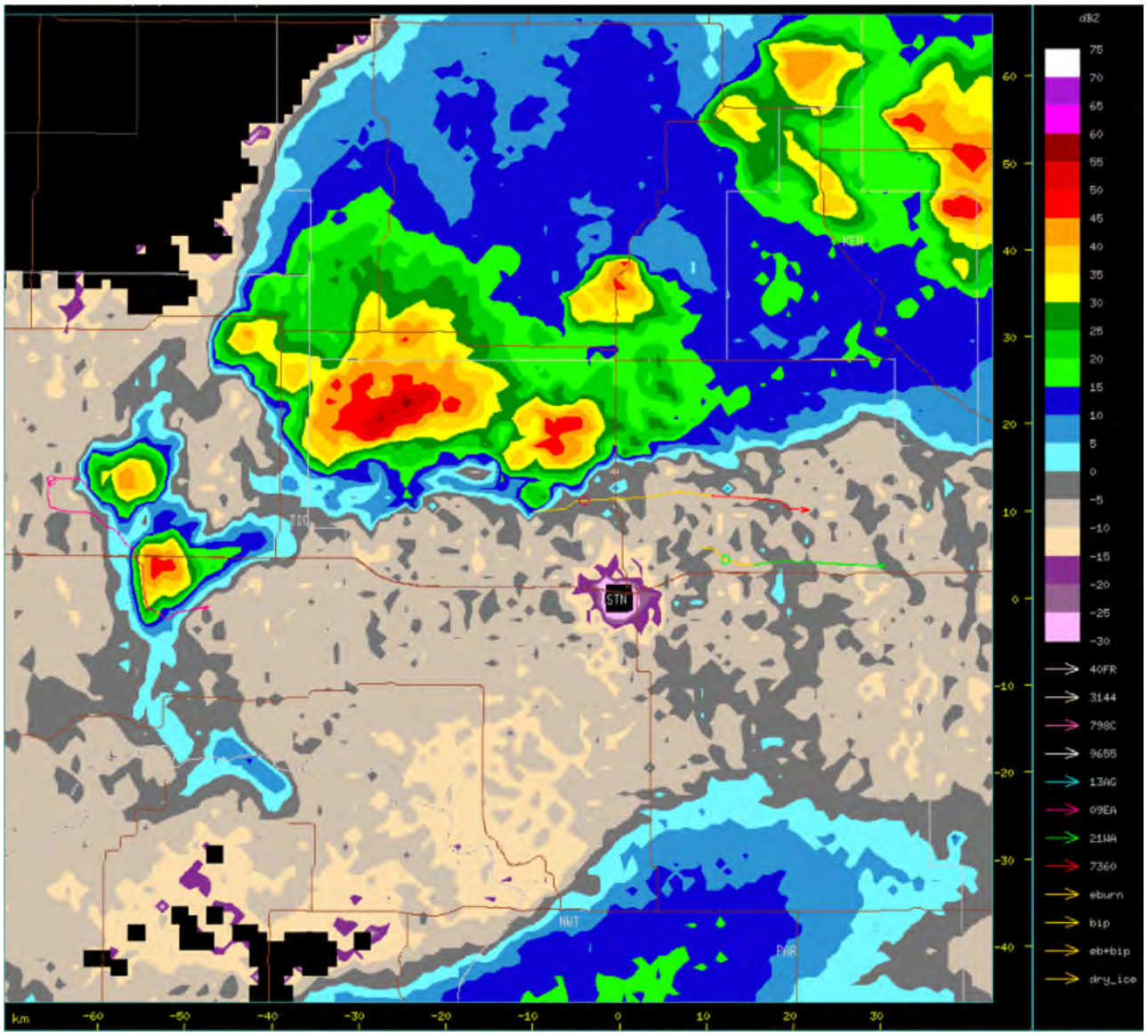

Fig. 23. A sample Stanley weather radar display showing cells north of Tioga, ND and northwest of Stanley, ND with aircraft running operations. Displayed are aircraft flight tracks for Seed 7 (pink), Seed 8 (green), and Seed 9 (red). The aircraft track length spans 10 minutes with an arrow representing the current location of the aircraft. A colored circle represents the location of the aircraft at the time of the last completed radar scan. Seed 8 and 9 have flight tracks that are partly gold indicating they had undergone seeding operations within the last 10 minutes. In this radar image, none of the aircrafts are actively seeding. Radar imagery courtesy of Mark Schneider, NDARB 2018.

10 METEOROLOGICAL SUMMARY - *by Charles Sassaman ARB Radar Meteorologist*

10.1 NDCMP Cloud Seeding Criteria

Radar meteorologists employ a set of guidelines to determine the most promising storms for seeding. These guidelines, established by the NDARB, include but are not limited to:

Rain Enhancement:

- Cloud bases lower than 8,000ft MSL
- Radar reflectivities at or higher than 35dbz at a 5km vertical height
- Obvious convective storm behavior
- Pilot reported rain shafts reaching the surface
- Pilot reported inflow between 100-500fpm

Hail Suppression: All the same criteria for rain enhancement **plus:**

- Radar reflectivities of 45dbz or greater, 5,000ft above the freezing level
- Pilot reported inflow between 500-800fpm and/or
- Hail reports from the general public/law enforcement

10.2 NDCMP Suspension Criteria

According to the project design and standard operating procedures, seeding operations are suspended for specific cells and/or project regions under certain circumstances. Suspension criteria include:

- Tornado Warnings or Funnel-Bearing Clouds
- Flash Flood Potential/Warnings/Flood Warnings/Areal Flood Advisories
- County Determinations (at the discretion of local weather modification authority)

Tornado Warnings issued by the National Weather Service (NWS) or funnel clouds/tornadoes observed by project personnel trigger the halting of seeding activities for a storm. In the case of NWS Tornado Warnings, nearby pilots may perform reconnaissance of the cell to confirm the presence of a funnel. If pilots are unable to confirm a funnel, seeding operations may immediately resume. However, if a tornado or funnel is confirmed by project personnel, there is an immediate 30-minute suspension of seeding for the funnel-bearing cell. Seeding may only resume 30-minutes after the funnel has dissipated. According to the NDARB operations manual, studies have not demonstrated that cloud seeding causes or intensifies tornadoes.

Fig. 24. Taylor Exizidis-Meier (Seed 4, N9798C) captures this image of a cold funnel cloud looking north at the District II buffer zone on August 4th, 2020. Shortly after it entered DII, reports of a touch down resulted in a National Weather Service issued Tornado Warning and seeding operations were suspended in accordance with the NDCMP suspension criteria. Seeding resumed once the threat had lifted. Photo by WMI Captain Taylor Exizidis-Meier.

Flood Potential may also trigger the suspension of seeding activities under several scenarios. A partial summary of the official NDARB Flood Suspension Criteria follows: If the National Weather Service issues a Flood Warning/Flash Flood Warning in a specific area, seeding is suspended. This usually means that an area has already experienced sufficient rainfall accumulation and additional heavy rain is expected. If that is the case, seeding is generally suspended for a region of the district and cannot be resumed within the warning area until the flood threat subsides. A second scenario is if a storm exhibits flash flooding potential as determined by the project radar meteorologists. This can be determined by investigating the rainfall rate (derived from the radar reflectivity values) and the storm motion. If the storm is stationary, a reflectivity value greater than 54.5 dBZ (indicating a rainfall rate greater than 2 inches per hour) would meet the criteria for seeding suspension. If the storm is in motion, the meteorologist must determine the flood potential based on cell speed, intensity, and expected rainfall rate. Seeding in this case may only be resumed when the storm system is no longer a flood threat.

Seeding operations may be suspended at any time at the request of the local weather modification authorities for entire districts or on a county-by-county basis. Rain-enhancement activities are frequently suspended late in the season as crops reach maturity.

10.3 Climatological Project Overview

10.3.1 JUNE

Typically, June is expected to be the most active month for vigorous convective development in western North Dakota. The 2020 NDCMP season followed suit, though overall monthly precipitation was generally below average. Both districts saw 12 days with seeding activity in June. During the first week of project, mid-level impulses provided the majority of atmospheric forcing while associated surface boundaries also provided convective triggers. This first week was characterized by a generally unstable atmosphere (CAPE > 1000 J/kg), with wind shear and low-level moisture sufficient for strong organized updrafts. Impressive inflows were observed along with robust hail threats. The latter parts of June saw a shift in the synoptic pattern as intermittent longwave troughs began sweeping across both districts. A nocturnal low-level jet (LLJ) was also occasionally present in June leading to moisture convergence and convective initiation at the nose of the LLJ, particularly in District I. While both districts recorded near-average monthly seeding activity on a per aircraft basis, District I saw generally more isolated severe thunderstorm activity than District II while northern regions saw more widespread rainfall.

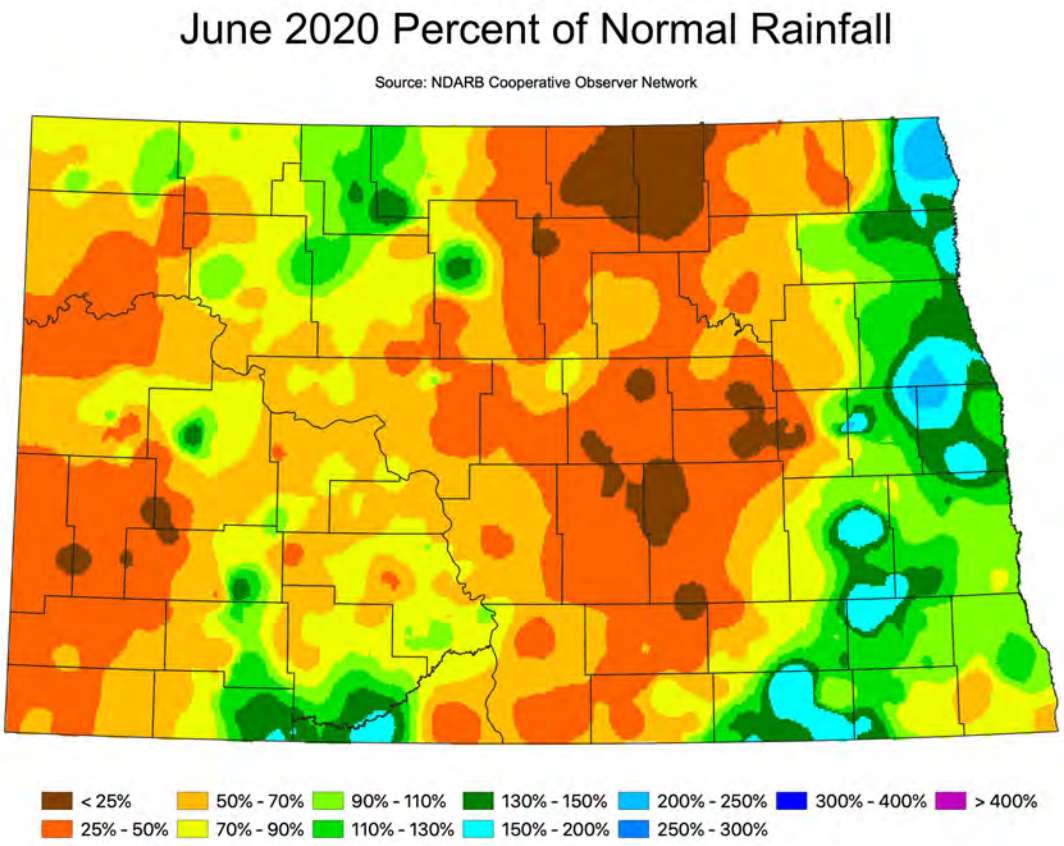

Fig. 25. A Percent of Normal Rainfall map produced by NDARB through their Cooperative Observer Network for the month of June. The majority of North Dakota experienced below average precipitation including the western and central regions of the state.

10.3.2 JULY

July proved to be a mixed bag of seeding opportunities ranging from multiple consecutive days of hail suppression to long periods of "no significant weather" days. While precipitation totals were above average, there were minimal rain-enhancement missions flown in July as most convective activity that was seeded surpassed hail threat criteria at some point in its life cycle. District I saw 8 days with seeding activity while the larger District II saw 12 days. A slow-moving blocking pattern set the stage for the beginning of the month as it settled over much of the US. However, its position favored the migration of multiple shortwave troughs into the project regions resulting in vigorous convective development and unseasonably wet conditions. As the blocking pattern dissipated in the second week of July, the associated ridge moved east opening the door to a more progressive synoptic pattern. Sporadic mid-level impulses would continue to induce the necessary instability and vertical motion to initiate convection in District II. By contrast, District I saw less frequent seeding opportunities during this time due to the pattern's northerly bias. Seeding opportunities waned later in the month as a strong high-pressure system amplified over the Midwest. Dry low levels resulted in reduced instability with convective cloud bases generally too high for effective rain enhancement. For both districts, seeding hours were lower than June due to the more stable synoptic setup. By the end of the month, with crops nearing maturity and hay needing to be bailed, all participating counties in both districts elected to suspend rain enhancement efforts for the remainder of the project.

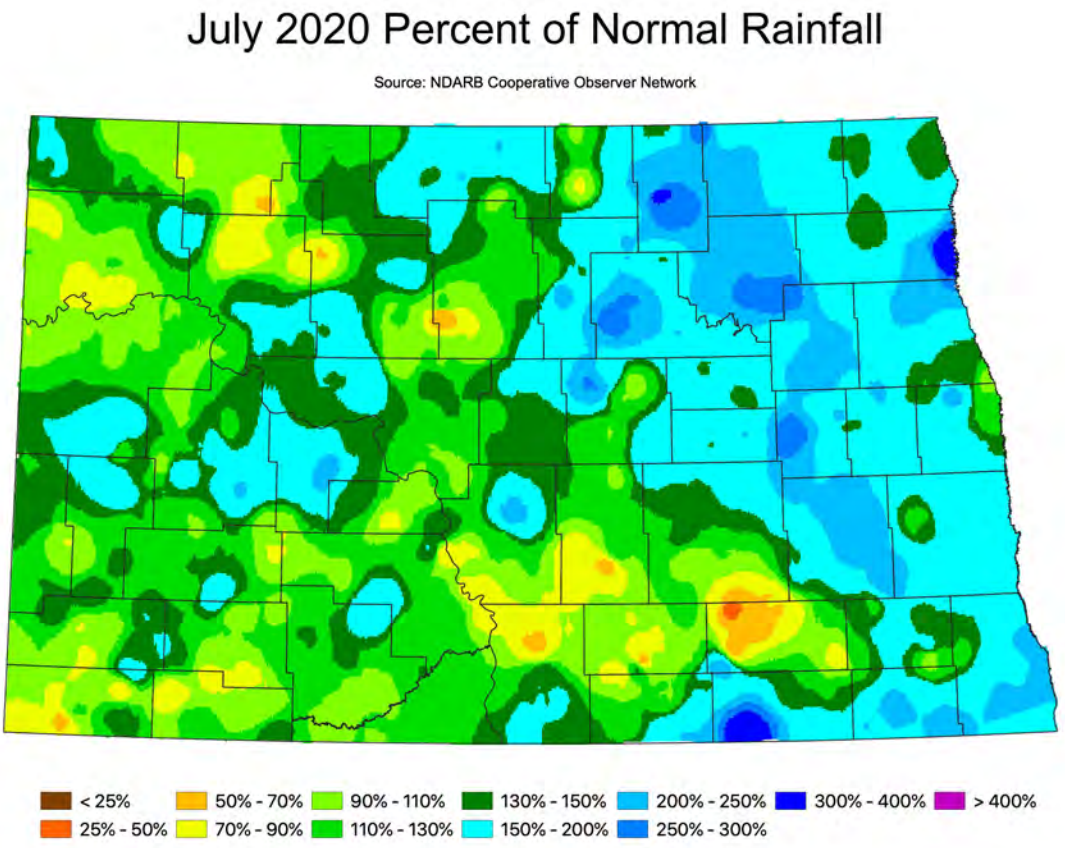

Fig. 26. A Percent of Normal Rainfall map for July produced by NDARB through their Cooperative Observer Network. Most of western North Dakota experienced near normal rainfall totals for the month after an unseasonably wet early July.

10.3.3 AUGUST

The onset of August was met with a strong mid-to-upper-level ridge situated over the Western US. As one would expect from persistent subsidence pattern (sinking air aloft), atmospheric instability and moisture was insufficient for appreciable convection, particularly in District II. With rain enhancement efforts suspended and poor thermodynamic profiles for deep convection, seeding opportunities were rarer in the final month for both districts. The more southern District I observed somewhat better moisture influx than District II and, as a result, saw a few more hail suppression flights and higher precipitation totals. As the month wore on, the large-scale setup did not improve substantially, and the infrequent operations relied mainly on passing shortwave troughs and nocturnal LLJ occurrences. While some longwave troughs did pass through the region, their convective potential was limited by subsidence from a competing ridge to the south choking off moisture. Though District I was able to end the project with several hail suppression operations in the final few days, the seeding season came to a quiet end for District II with eighteen straight days without operations.

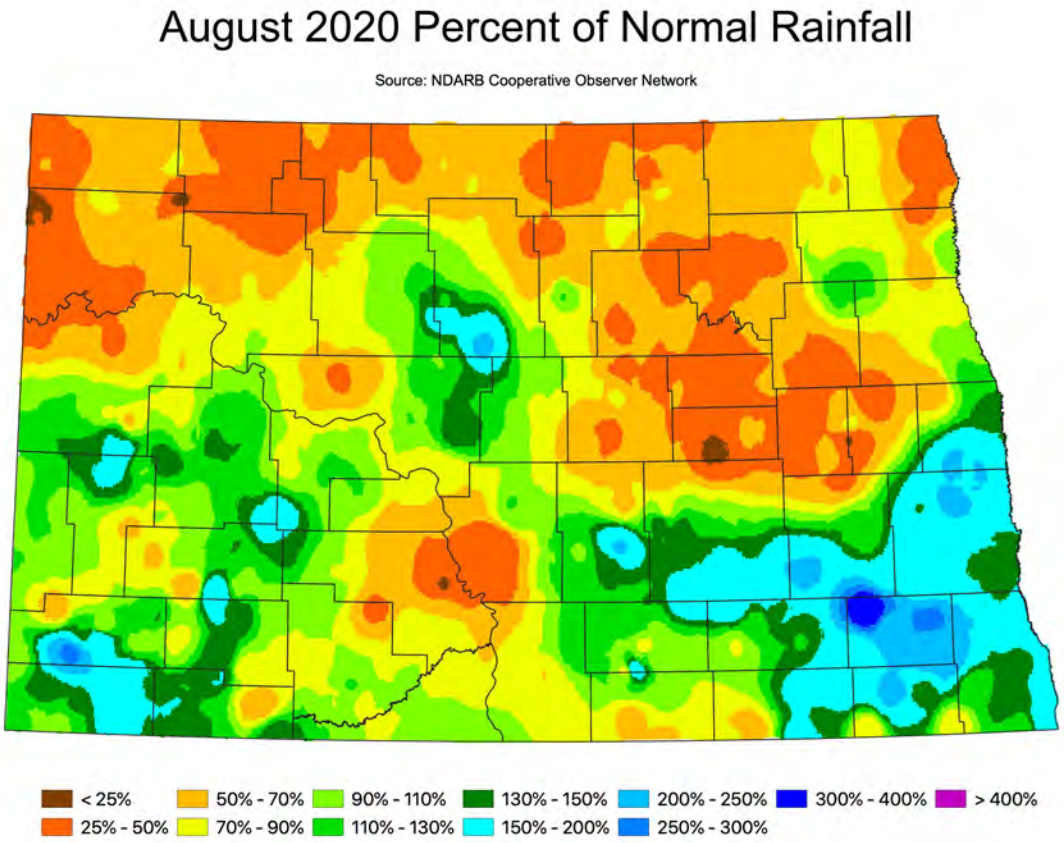

Fig. 27. A Percent of Normal Rainfall map for August produced by NDARB through their Cooperative Observer Network. Most of northwestern North Dakota experienced well below average precipitation, while southwestern North Dakota saw areas of above average precipitation within District I.

11 PROJECT RECORD KEEPING

NDCMP record keeping is completed on the Apple iPad. The iPad is widely used by many aviation companies, including WMI who have used it to replace the need for bulky paper charts. The iPad features the ARB's "PARS" (Pilot Aircraft Recordkeeping System) software and is able to track position and altitude data. The iPad receives this data from its built-in GPS. This data is used to create the flight form as well as accurate maps, with seeding areas depicted as entered by the flight crew. Two additional programs, *ARBSync* and *ChemInv*, are included on the iPad to execute data uploads to the ARB database, and to monitor seeding chemicals and flares at NDCMP field sites. The iPad allows for speedy uploads of the data to ARB's database via Wi-Fi.

All aircraft were equipped with an ADS-B receiver (Automatic Dependent Surveillance - Broadcast) to access the FAA weather information provided by this network. The weather information can be displayed on *ForeFlight* using either the ARB or WMI provided iPad. While the radar depictions available from ADS-B are delayed, they are still an excellent tool for the flight crews to aid in situational awareness and communications with the radars.

Fig. 28. (Left) An example of the weather radar onboard N709EA (Seed 7) during a seeding mission. Photo by WMI Captain Alex Sailsbury. (Right) Seed 4 (N9798C) uses the ForeFlight display with ADS-B during a base-seeding mission on June 9th, 2020. Photo by WMI Captain Taylor Exizidis-Meier.

12 WMI AND NDARB PROJECT PERSONNEL

12.1 Ground School

The 2020 North Dakota Cloud Modification Project Ground School was conducted May 26th - 28th, 2020 using an online meeting platform for the first time this year due to COVID-19 restrictions. All aspects of the program were discussed, including responsibilities of personnel, cloud physics, opportunity recognition, use of seeding chemicals, project documentation, safety procedures, PARS iPad training, and selected examples from prior projects that helped illustrate efficient cloud seeding procedures.

Fig. 29. The WMI aircrew takes a minute to spell out NDCMP20 during their online training on May 21st, 2020 with WMI Administration. Due to COVID-19 restrictions and concerns, all 2020 NDCMP training was conducted remotely. Pictured top-bottom, left to right – Taylor Exizidis-Meier, Tyler Couch, Damien Gehler, Alex Bestul, Alex Sailsbury, Jacob Berg, and Kirk Hamilton, and the hand of Jake Van Ornum.

Numerous questions typically surface during the project as problems arise and remedies are explored. It is invaluable to have experienced personnel in the field during the season to resolve these problems. ARB Director Darin Langerud and ARB Chief Meteorologist Mark Schneider were always available for advice and answers whenever their radar meteorologists needed guidance; all project personnel were provided a link to online copies of the NDCMP Operations Manual and Radar Applications Manual prior to the season start.

Jody Fischer (WMI Director of Flight Operations) and Kirk Hamilton (WMI Chief Pilot) provided support for WMI pilot personnel during the season. Fischer started on the NDCMP project as an intern in 1999 and has been involved with the project since. Hamilton started on the NDCMP project as a PIC in 2016. Prior to the start of the 2020 season, Hamilton and Fischer spent a considerable amount of time with each pilot to ensure they were prepared and knowledgeable with the focus on safety. They also provided training and support during the NDCMP pre-project 2020 ground school and filled in for pilots as needed when vacations or for any unforeseen events occurred.

12.2 WMI Pilots

Each pilot was checked out in his designated aircraft before the beginning of the project. All PIC's had previous experience cloud seeding as a PIC and/or intern. Four of the six PICs (Berg, Gehler, Sailsbury, Couch) and the relief pilots (Fischer and Hamilton) had previous experience cloud seeding as PIC on both the NDCMP and on other WMI projects. Two of the PICs (Exizidis-Meier and Bestul) were intern co-pilots on the 2019 NDCMP. 2020 was a stellar year for pilot retention and WMI remains committed to retention where possible.

WMI training pilots were Jody Fischer and Kirk Hamilton. During training, all pilots got to fly with at least one of the two instructors to ensure that they were familiar with the airplane systems and the operation of the seeding equipment. The pilots were instructed on airspeeds and power settings used during seeding missions, as well as safe operating procedures. These flights provided quality assurance to standardize the WMI procedures for each pilot. All of the pilots were involved in the pre-season maintenance and flight-testing of the aircraft and seeding equipment.

WMI project pilots requested personal time off at various parts during the summer. As part of WMI's commitment to provide uninterrupted service, a relief pilot was made available for such occasions. This happened once during the 2020 season. Hamilton replaced for Jacob Berg (Seed 3) in Dickinson, ND from June 12th - 15th, 2020.

Fig. 30. Alex Sailsbury (WMI King Air Captain) takes a crew photo with District I Captains Tyler Couch and Alex Bestul on the ferry flight from Bowman to Fargo on May 29th, 2020.

12.3 Co-Pilot Internship

The Pilot Internship Program was initially begun in 1974 by the Bureau of Reclamation. A Memorandum of Understanding (MOU) between the ARB and the University of North Dakota has been in place since 1975.

This year due to the global pandemic the University of North Dakota cancelled all spring and summer semester internship programs. For the first time in forty-five years the NDCMP internship faced a significant hurdle. Prior to this notification, the co-pilots had either completed or been enrolled in the *Applied Weather Modification* course at the University of North Dakota, and had been interviewed and selected from the class for their internships by Mike Poellot, Chair of Atmospheric Sciences at UND and Kelli Schroeder of the ARB. Since the pilot internship program is funded by the ARB, the ARB was able to directly hire the co-pilots as temporary state employees and provide these students with summer work.

Ms. Schroeder, as in past seasons, oversaw the program for the ARB. The intern pilots were paid an hourly wage and were required to maintain a timesheet of their project activities. As of the completion of the 2020 program, the program has provided training and experience for 392 pilots. All of the co-pilot interns returned to school before the end of August. A copy of the NDCMP Pilot and Meteorologist Internship Final Report may be requested from Ms. Schroeder.

Fig. 31. Cade Kissinger, ARB Intern Pilot, takes the controls of Seed 3 (N37360) on July 7th, 2020. Photo by WMI Captain Jacob Berg.

WMI provides, for a nominal charge, each season's co-pilot interns with flight instruction and endorsements for High Altitude and or High Performance training to give them the proper US Federal Aviation Administration certifications to act as pilots in the WMI aircraft used on the NDCMP. This allows the interns to log flight time in the aircraft, giving them hands-on experience that is far more beneficial for them. These certifications are not normally earned during flight training at UND. The flights involve several takeoffs and landings as well as flight operations at 25,000 feet.

Due to COVID-19, the King Air rotation was cancelled this season. This meant that only a few of the interns required a High Altitude Endorsement. Jacob Berg conducted training on a ferry flight May 29th, 2020 for intern Jordan Provost. Kirk Hamilton conducted training with interns Michael Steinke on June 1st, 2020 and with Ryan Starkey on June 13th, 2020. Interns who required the high performance endorsement were able to obtain this from their respective PIC's at the start of the project.

12.4 NDARB Staff

All radar and intern meteorologists were employed by the NDARB. Three meteorology interns were chosen to spend the season as assistant meteorologists on project. District I (Nate Woltmann), District II (Ben Stoinski), and one intern (Harrison Rademacher) was selected to assist with forecasting from the Bismarck office. Traditionally each intern would spend approximately two weeks rotating through each of the other sites during project; however, as a result of COVID-19 concerns the rotation this season was cancelled for the health and safety of the field personnel. The NDCMP Meteorology Internship Program began in 1996 and to date has provided hands-on radar, operations and forecasting experience for 64 meteorology undergraduates.

12.5 NDARB Administration

Director Darin Langerud oversees the NDCMP operations for the ARB. Chief Meteorologist Mark Schneider manages the radar and intern meteorologists. Business Manager, Ms. Kelli Schroeder handles the program funding, contracts, and the pilot intern program. Mr. Daniel Brothers, Meteorologist, trains and oversees the intern forecaster as well as performing office duties including record keeping, iPads, the ARB rain gauge network, and record quality control. Mr. Langerud and Mr. Schneider are Weather Modification Association (WMA) Certified Weather Modification Managers, and Mr. Brothers is a WMA Certified Operator.

ND State Water Commission IT technician, Paul Moen handled issues with the TITAN software and hardware systems in both radars. Moen was also the architect behind the iPad aircraft data recording software.

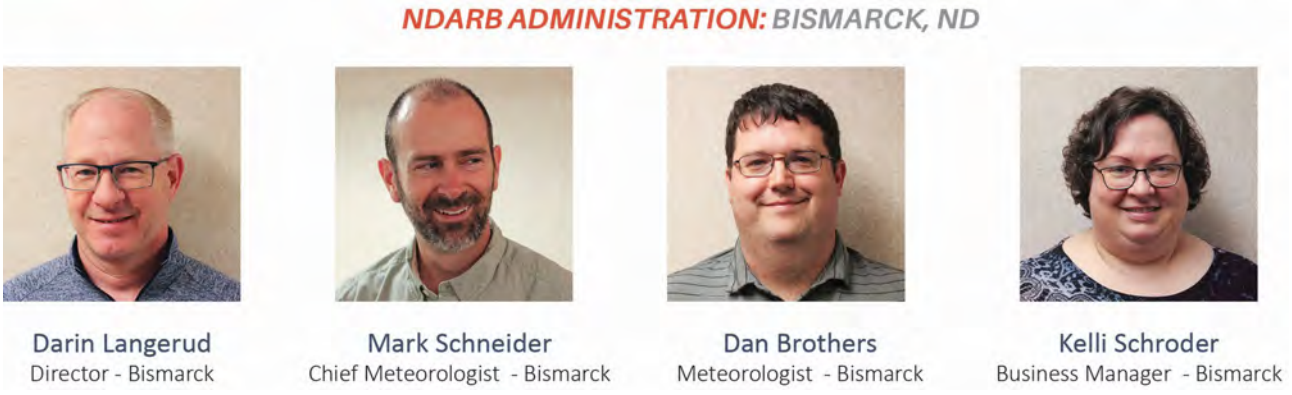

Fig. 32. NDARB Administration Team located in Bismarck, ND.

12.6 Weather Modification International Administration

Jody Fischer, WMI Director of Flight Operations was the Primary Project Manager for the 2020 season. Mr. Fischer has been involved with the project since 1999 when he joined the team as an intern pilot in Watford City. He returned the following two years as a Seneca captain, then as C340A captain and continued that role for the next 4 seasons until he was assigned on other WMI's international projects. Fischer has worked at WMI full time since 2000.

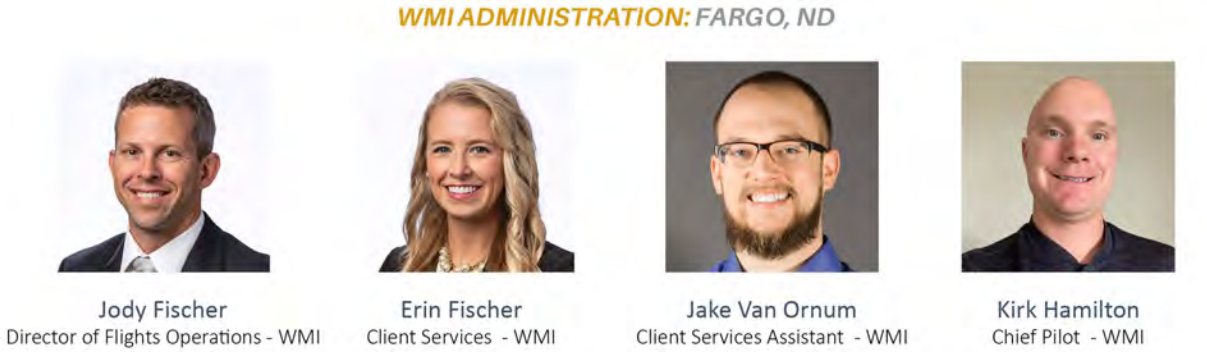

Fig. 33. WMI – NDCMP Administration Team located in Fargo, ND.

Kirk Hamilton, WMI Chief Pilot, served as the Field Representative for WMI during the season. This was his fifth season on the North Dakota Cloud Modification Project. Hamilton has also been a PIC for WMI on winter projects in Wyoming and California, as well as a PIC on a rainfall enhancement project in India.

Hamilton and Fischer were responsible for hiring and training the project pilots, overseeing aircraft operations, aircraft and equipment maintenance, and providing relief pilot duties.

Pat Sweeney, President of WMI and Bruce Boe, WMI VP of Meteorology served as Co-Project Managers in case Mr. Fischer needed to travel outside the state. Mr. Fischer is a Weather Modification Association Certified Weather Modification Operator and Mr. Boe is a WMA Certified Manager. Sweeney began his career in Weather Modification in Bowman, ND in 1975. He currently serves as the CEO, after gaining controlling interest of the company in 1990. Mr. Boe assumed his present position at WMI in 2001. Prior to coming to WMI he served as Director of the ARB for 12 years.

Dennis Afseth, WMI Director of Electronics, oversaw the installation and maintenance of the datalogger computers and electronics in the aircraft, including *AirLink*.

12.7 NDCMP Project Personnel Pictures

DISTRICT I: Bowman, ND

Fig. 34. (Left) Seed 1 - Tyler Couch (WMI Captain) and Kelsey Carrabre (ARB Pilot Intern). Pictured in the back seat is Harrison Rademacher (ARB Forecast Meteorologist). (Right) Seed 2 - Alex Bestul (WMI Captain) and Maria Cole (ARB Pilot Intern). Pictured in the back seat is Nathan Woltmann (ARB Intern Meteorologist).

Fig. 35. The District I team poses in front of the Seneca and Bowman radar, pictured from left to right: Nathan Woltman (ARB Intern Meteorologist), Kelsey Carrabre (ARB Pilot Intern), Maria Cole (ARB Pilot Intern), Alex Bestul (WMI Captain) (WMI Captain), Tyler Couch (WMI Captain), and Kyle Pederson (ARB Radar Meteorologist). Photo submitted by Nathan Woltmann.

DISTRICT II: Stanley, ND

Fig. 36. The Stanley meteorology team and the Seed 4 captain take a break to capture a group photo in front of N9798C and the Stanley radar. Pictured left to right – Charles Sassaman and Corey Clay (ARB Radar Meteorologists), Benjamin Stoinski (ARB Intern Meteorologist), and Taylor Exizidis-Meier (WMI Captain). Photo submitted by Taylor Exizidis-Meier.

Fig. 37. Seed 4 (left to right) – Taylor Exizidis-Meier (WMI Captain) and Cody Kleinsteuber (ARB Pilot Intern) are all smiles before their mission in N9798C.

DISTRICT II: Watford City, ND

Fig. 38. Seed 5 (left to right) - Damian Gehler (WMI Captain) and Michael Steinke (ARB Intern Pilot) snap a picture before take-off from Kenmare, ND in N121WA.

DISTRICT II: Dickinson, ND

Fig. 39. Seed 3 (left to right) – Cade Kissinger (ARB Intern Pilot) and Jacob Berg (WMI Captain) take a selfie in N37360.

DISTRICT II: Williston, ND

Fig. 40. Seed 7 (left to right) – Jordan Provost (ARB Intern Pilot) and Alex Sailsbury (WMI Captain) give a thumbs up for cloud seeding in the King Air C90 (N709EA).

Fig. 41. Vacation Rover (left to right) –Alex Sailsbury (WMI Captain) and Ryan Starke (ARB Intern Pilot - Vacation Rover) stand in front of the King Air C90 (N709EA) on the ramp in Williston, ND.

13 PUBLIC RELATIONS

The North Dakota Cloud Modification Project has a rich history of community event participation, education, and public outreach; however, this year due to the global pandemic many events were canceled as social distancing practices were encouraged statewide. The Stanley Fly-In Breakfast held on July 18th, 2020 was the only public event that occurred this summer. The WMI aircraft was on static display and the Stanley crew was available for questions.

Despite fewer opportunities for community engagement, this did not completely prevent project personnel in both districts from their continued acts of volunteerism at their respective airports. While maintaining social distancing requirements and ND Smart Start guidelines, pilots and meteorologists took turns mowing, spraying weeds, assisting with aircraft fuelings, and providing general hospitality to airport and radar visitors. Their professionalism, willingness to pitch in, and positive attitude is an example for future projects to look upon.

14 PROGRAM AWARDS

NDARB recognizes field personnel professionalism and dedication to the project with the presentation of the following project awards. Nominations are taken from project personnel, WMI administration, and ARB staff the last week of project and are carefully considered. This season two awards were presented – the Wilbur E. Brewer Professional Award and the Hans P. Ahlness Outstanding Intern Award.

Wilbur E. Brewer Professionalism Award

Named in honor of one of the founders of WMI and longtime NDCMP advocate, this award was presented to meteorologist Kyle Pederson for providing every effort to make the 2020 NDCMP a success. Kyle demonstrated true passion for the NDCMP and always strived to give his 100% by constantly being aware of storms and seeing the "big picture" during operations. When needed, this Bowman resident also provided support to District 2 operations by guiding Seed 7 through McKenzie County during a particularly challenging mission and alerting Stanley Radar about impending storms.

Hans P. Ahlness Outstanding Intern Award

A desire to learn and further their education attracts interns to the NDCMP. This award is given to the intern who had the greatest positive impact on the project and its daily operations and was awarded to intern pilot Ryan Starkey. Ryan consistently demonstrated a great work ethic, attitude, and good sense of humor. He also volunteered his time helping airport crews where he was able. His coworkers feel he went above and beyond expectations. In honor of Hans P. Ahlness, longtime NDCMP participant and great mentor to hundreds of North Dakota interns, it is an honor to have the Intern Award bear his name going forward.

15 CONTRACTOR'S SUMMARY

This summer was Weather Modification International's 60th season providing operational cloud seeding services for the North Dakota Cloud Modification Project. Although the project design has remained the same throughout the period, County participation has changed significantly. Unfortunately, this was the second consecutive season that a County removed funding and participation from the NDCMP. Ward County voted on June 9th, 2020 against continuation via ballot measure in the June Primary Election. Since Ward County did not renew their authority prior to the vote, no cloud seeding services were provided for Ward County from June 1st - 9th, 2020. The impact of their removal included the loss of one aircraft and its crew for the 2020 season. For the first time in decades an aircraft was not based at the Kenmare Airport. An economic impact was felt not only by WMI but also by the community of Kenmare, ND. In 2018 Burke County exited the project after a 4-year trial.

It has become evident that the future of the NDCMP must be seriously reviewed. As each district continues to examine their annual budget, it will take significant renewed public engagement in 2021 to increase program awareness. WMI remains steadfast in efforts to promote and showcase the positive impact of the NDCMP. WMI would like to thank the Friends of Ward County group and the North Dakota Weather Modification Association (NDWMA) for their work educating the voters of Ward County. A number of promotional materials on the benefit of the NDCMP were shared through various media platforms.

The global pandemic (COVID-19) created a variety of additional hurdles this season. Prior to the start of the project, the pandemic forced annual pre-project meetings held in Bismarck, ND to be online only and restricted pilot training to one-on-one training. Travel restrictions, social distancing regulations, cockpit and office cleaning procedures, and unforeseen changes during the season were handled extremely well by the Field personnel throughout the season. WMI and ARB personnel maintained healthy crews and all storms worthy of treatment according to the current operational guidelines were seeded in a timely manner. Coordination during the season required all Field personnel remain flexible and alert to the ever-changing virus. WMI recognizes these efforts and thanks the 2020 NDCMP team for a job well done!

WMI would like to recognize ARB staff members - Darin Langerud, Mark Schneider, Kelli Schroeder, and Dan Brothers for their consistent management and program direction. Personnel must be hired and trained, equipment maintained and improved, seeding chemicals and flares obtained, and procedures put in place to allow for smooth project operations. The ARB staff members have several years of experience and WMI appreciates working with such professionals.

In closing, WMI invites comments from the ARB regarding this summer's project and improvements for continued operations. Thank you for another great season!

Fig. 42. A spectacular western ND sunset casts it colors against the District II aircraft on June 23rd, 2020. Photo by WMI Captain Tyler Couch.

APPENDIX ITEMS

Appendix A: Aircraft Activity Tables

District I "Hybrid" Cloud Top Aircraft – N37360
District I Cloud Base Aircraft – N39655, N33144

District II "Hybrid" Aircraft – N37360
District II Cloud Top Aircraft, Turbo-Prop – N709EA
District II Cloud Base Aircraft – N9798C, N121WA, N13AG

Appendix B: Aircraft Specifications

Piper Seneca II
Cessna 340A (Hybrid)
King Air C90

Appendix C: NOAA Final Operations Reporting

Appendix A

District I – "Hybrid", Cessna 340A

2020 DISTRICT I FLIGHT SUMMARY
(C340)

DATE	HAIL	RAIN	RECON	OTHER	DAILY TOTAL	RUNNING TOTAL	MAINTENANCE (Contractor Expense)	GENERATORS - Cessna ONE (hours burned)	GENERATORS - Cessna TWO (hours burned)	GENERATORS - Cessna ONE (grams burned)	GENERATORS - Cessna TWO (grams burned)	FLARES (grams)
	(---------all flight times in hundredths of hours----------)											
06/03/20	1.00	1.10			2.10	2.10						620
06/04/20			1.77		1.77	3.87						
06/07/20	1.17		0.14		1.31	5.18			0.37		216.45	150
06/08/20	1.94				1.94	7.12						290
06/09/20		1.34			1.34	8.46		0.26		76.05		
06/13/20					0.00	8.46	0.76					
06/14/20	1.62				1.62	10.08			0.72		421.20	
06/17/20					0.00	10.08	0.50					
06/18/20		1.69			1.69	11.77	0.56					380
06/20/20		1.73			1.73	13.50						220
06/23/20					0.00	13.50	3.48					
06/27/20	3.34				3.34	16.84			0.83		485.55	1555
07/01/20					0.00	16.84	3.64					
07/03/20			0.33		0.33	17.17						
07/23/20	1.89				1.89	19.06	0.45					500
07/30/20	1.75				1.75	20.81						1140
07/31/20	3.63		0.05		3.68	24.49			0.85		497.25	365
08/11/20			1.55		1.55	26.04						
08/12/20	1.42				1.42	27.46			0.35		204.75	75
08/14/20	1.07				1.07	28.53			0.43		251.55	150
08/24/20					0.00	28.53	0.41					
08/28/20					0.00	28.53	0.39					
					0.00	28.53						
TOTALS	**18.83**	**5.86**	**3.84**	**0.00**	**28.53**	**28.53**	**10.19**	**0.26**	**3.55**	**76**	**2,077**	**5,445**

TOTAL AgI RELEASED BY AIRCRAFT: 7,598 grams

TOTAL FLIGHT HOURS CONTRACTED:	30.00
FLIGHT HOURS FLOWN TO DATE:	28.53
FLIGHT HOURS REMAINING :	1.47
PERCENT OF FLIGHT HOURS USED:	95%

District I – Cloud Base Aircraft, Seneca II

2020 DISTRICT I FLIGHT SUMMARY
CLOUD - BASE (Seneca)

					DAILY	RUNNING	MAINTENANCE	GENERATORS - Seneca		GENERATORS - Seneca		FLARES
DATE	HAIL	RAIN	RECON	OTHER	TOTAL	TOTAL	(Contractor	ONE	TWO	ONE	TWO	
	(---------all flight times in hundredths of hours----------)						Expense)	(hours burned)		(grams burned)		(grams)
06/01/20					0.00	0.00	0.36					
06/02/20					0.00	0.00	0.63					
06/03/20	4.80		0.91		5.71	5.71	0.56	0.08	2.57	16	1,033	300
06/04/20	4.30		1.27	0.52	6.09	11.80			1.84		740	300
06/07/20	4.29		0.59	1.55	6.43	18.23			2.03		816	225
06/08/20	3.50				3.50	21.73			1.61		647	150
06/14/20	5.41		0.66		6.07	27.80	0.28		3.66		1,471	675
06/16/20	1.82				1.82	29.62			0.77		310	
06/19/20	6.70				6.70	36.32		3.51	0.79	706	318	
06/20/20	6.18		1.45		7.63	43.95	0.28	1.57	1.95	316	784	600
06/21/20	2.60			0.49	3.09	47.04			0.73		293	
06/22/20		1.09			1.09	48.13		0.65		131		
06/23/20					0.00	48.13	4.56					
06/24/20					0.00	48.13	2.38					
06/27/20	5.22				5.22	53.35		0.11	2.94	22	1,182	525
06/28/20	2.63			0.62	3.25	56.60			1.22		490	150
06/30/20			2.05		2.05	58.65						
07/02/20			1.03		1.03	59.68						
07/03/20			0.64	0.59	1.23	60.91						
07/04/20	6.86		0.62	0.61	8.09	69.00			3.69		1,483	600
07/05/20	4.87		1.47	0.49	6.83	75.83			3.26		1,311	450
07/06/20	1.05				1.05	76.88			0.64		257	
07/07/20			0.96	0.60	1.56	78.44						
07/08/20	4.03			0.91	4.94	83.38			2.78		1,118	225
07/10/20	1.60		1.94		3.54	86.92	0.44	0.39		78		
07/16/20					0.00	86.92	0.64					
07/21/20					0.00	86.92	0.55					
07/23/20	4.45				4.45	91.37			3.53		1,419	75
07/28/20					0.00	91.37	0.52					
07/30/20	4.19				4.19	95.56		0.05	3.18	10	1,278	675
07/31/20	3.41		0.57		3.98	99.54			2.33		937	375
08/04/20	1.60				1.60	101.14			0.98		394	225

District I – Cloud Base Aircraft, Seneca II

08/05/20					0.00	101.14	0.43					
08/09/20	2.78		0.69		3.47	104.61			1.87		752	300
08/11/20	6.09				6.09	110.70		0.07	4.08	14	1,640	1050
08/12/20				1.38	1.38	112.08						
08/14/20	4.66		0.55	1.89	7.10	119.18			2.58		1,037	675
08/18/20					0.00	119.18	0.53					
08/24/20					0.00	119.18	0.71					
08/27/20	2.21		0.97		3.18	122.36			1.49		599	225
08/28/20	3.15				3.15	125.51			1.92		772	75
					0.00	125.51						
TOTALS	**98.40**	**1.09**	**16.37**	**9.65**	**125.51**	**125.51**	**12.87**	**6.43**	**52.44**	**1,292**	**21,081**	**7,875**

TOTAL AgI RELEASED BY BASE AIRCR/ 30,248 grams

TOTAL FLIGHT HOURS CONTRACTED:	110.00
FLIGHT HOURS FLOWN TO DATE:	125.51
FLIGHT HOURS REMAINING :	-15.51
PERCENT OF FLIGHT HOURS USED:	114%

District II – "Hybrid", Cessna 340A

2020 DISTRICT II FLIGHT SUMMARY
(C340)

DATE	HAIL	RAIN	RECON	OTHER	DAILY TOTAL	RUNNING TOTAL	MAINTENANCE (Contractor Expense)	GENERATORS - Cessna ONE	GENERATORS - Cessna TWO	GENERATORS - Cessna ONE	GENERATORS - Cessna TWO	FLARES
	(---------all flight times in hundredths of hours---------)							(hours burned)		(grams burned)		(grams)
06/03/20	1.56				1.56	1.56						260
06/06/20		3.00			3.00	4.56		1.04		304		
06/15/20	2.41				2.41	6.97			0.63		369	
06/17/20			0.66		0.66	7.63						
06/28/20		3.56			3.56	11.19		1.10	0.51	322	298	
06/29/20	2.20				2.20	13.39			1.44		842	225
06/30/20	2.46				2.46	15.85		0.45	1.32	132	772	750
07/01/20				1.12	1.12	16.97						
07/03/20	2.43				2.43	19.40						820
07/04/20	1.50	1.67			3.17	22.57		0.54	0.75	158	439	
07/08/20	3.17			1.27	4.44	27.01		0.18	1.63	53	954	
07/10/20	3.91				3.91	30.92		0.82	1.31	240	766	450
07/24/20			1.76		1.76	32.68						
08/05/20					0.00	32.68	1.35					
08/09/20	2.31				2.31	34.99			0.84		491	
08/11/20			1.04		1.04	36.03						
					0.00	36.03						
TOTALS	**21.95**	**8.23**	**3.46**	**2.39**	**36.03**	**36.03**	**1.35**	**4.13**	**8.43**	**1,208**	**4,932**	**2,505**

TOTAL AgI RELEASED BY AIRCRAFT: 8,645 grams

TOTAL FLIGHT HOURS CONTRACTED:	55.00
FLIGHT HOURS FLOWN TO DATE:	36.03
FLIGHT HOURS REMAINING :	18.97
PERCENT OF FLIGHT HOURS USED:	66%

District II – Cloud Top Aircraft, Turbo-Prop

2020 DISTRICT II FLIGHT SUMMARY
CLOUD - TOP (TURBO-PROP ONLY)

DATE	HAIL	RAIN	RECON	OTHER	DAILY TOTAL	RUNNING TOTAL	MAINTENANCE (Contractor Expense)	DRY ICE (pounds)	FLARES (grams)
06/01/20					0.00	0.00	1.35		
06/03/20	1.78				1.78	1.78			960
06/06/20	2.54		2.07		4.61	6.39			1460
06/08/20	3.48				3.48	9.87		130.84	515
06/09/20	1.78	4.30			6.08	15.95		292.53	500
06/10/20		2.47			2.47	18.42		195.21	
06/14/20	6.26				6.26	24.68			2805
06/17/20	1.93			0.93	2.86	27.54		200.00	
06/25/20	3.53	2.68			6.21	33.75		394.74	375
06/27/20	3.76				3.76	37.51		200.00	280
06/28/20	3.95				3.95	41.46			550
06/29/20	3.54				3.54	45.00		144.92	390
06/30/20		1.82		0.98	2.80	47.80		82.16	
07/02/20	2.04	2.08			4.12	51.92		316.09	
07/03/20	4.33				4.33	56.25		200.00	920
07/04/20			1.05		1.05	57.30			
07/05/20	2.57			0.64	3.21	60.51		46.10	400
07/06/20	3.54		0.95		4.49	65.00			1670
07/10/20	4.63				4.63	69.63		200.00	360
07/13/20	1.56				1.56	71.19		102.41	
07/17/20	3.56				3.56	74.75		200.00	
07/24/20	1.97				1.97	76.72		172.20	75
07/29/20		0.96			0.96	77.68		2.27	
07/30/20			0.21		0.21	77.89			
07/31/20	1.76				1.76	79.65		56.20	
08/04/20	2.70				2.70	82.35		122.52	
08/09/20	3.35				3.35	85.70		200.00	360
08/10/20					0.00	85.70	1.54		
08/11/20					0.00	85.70	2.08		
08/13/20	1.95				1.95	87.65		56.68	
08/28/20			1.10	0.65	1.75	89.40			
					0.00	89.40			
TOTALS	**66.51**	**14.31**	**5.38**	**3.20**	**89.40**	**89.40**	**4.97**	**3,314.87**	**11,620**

TOTAL AgI RELEASED BY C90 AIRCRAFT: 11,620 grams
TOTAL DRY ICE USED ON PROJECT: 3,314.87 pounds

TOTAL FLIGHT HOURS CONTRACTED:	100.00
FLIGHT HOURS FLOWN TO DATE:	89.40
FLIGHT HOURS REMAINING:	10.60
PERCENT OF FLIGHT HOURS USED:	**89%**

District II – Cloud Base Aircraft, Seneca II

2020 DISTRICT II FLIGHT SUMMARY
CLOUD - BASE (Seneca)

					DAILY	RUNNING	MAINTENANCE	GENERATORS - Senecas		GENERATORS - Senecas		FLARES
DATE	HAIL	RAIN	RECON	OTHER	TOTAL	TOTAL	(Contractor	ONE	TWO	ONE	TWO	
	(---------all flight times in hundredths of hours---------)						Expense)	(hours burned)		(grams burned)		(grams)
06/01/20					0.00	0.00	2.86					
06/03/20	3.91				3.91	3.91		1.31	1.07	263	430	
06/04/20			0.87		0.87	4.78						
06/06/20	5.47	6.78			12.25	17.03	0.16	3.04	2.80	611	1,126	450
06/07/20			2.27		2.27	19.30						
06/08/20	3.93	7.96			11.89	31.19		5.88	0.21	1,182	84	
06/09/20		5.60			5.60	36.79		2.21		444		
06/14/20	12.39				12.39	49.18	0.28	1.35	5.94	271	2,388	1875
06/15/20	5.46			1.75	7.21	56.39	1.83	0.72	2.48	145	997	825
06/16/20					0.00	56.39	2.19					
06/17/20	6.51			1.60	8.11	64.50		0.08	3.16	16	1,270	1500
06/18/20					0.00	64.50	1.98					
06/23/20					0.00	64.50	0.34					
06/25/20	7.77	2.21			9.98	74.48		5.21	0.74	1,047	297	150
06/27/20	7.34				7.34	81.82		2.03	3.12	408	1,254	600
06/28/20	5.98				5.98	87.80		2.59	0.79	521	318	
06/29/20	6.57		0.77		7.34	95.14		0.03	4.43	6	1,781	1425
06/30/20	2.01			1.82	3.83	98.97	1.68		1.16		466	525
07/02/20	6.41				6.41	105.38		0.75	1.58	151	635	
07/03/20	9.35				9.35	114.73		4.30	2.42	864	973	150
07/04/20	5.56			0.72	6.28	121.01		0.61	2.51	123	1,009	150
07/05/20	9.72			0.98	10.70	131.71		0.91	4.58	183	1,841	1050
07/06/20	5.53	2.10	2.65		10.28	141.99		2.24	2.90	450	1,166	600
07/07/20	1.72	1.65			3.37	145.36		1.25	0.39	251	157	
07/08/20	6.47			1.77	8.24	153.60			3.69		1,483	225
07/09/20					0.00	153.60	1.05					
07/10/20	9.56				9.56	163.16	0.46	0.09	4.11	18	1,652	1125
07/11/20	2.23				2.23	165.39		0.41	1.29	82	519	675
07/13/20	3.78				3.78	169.17	0.30		1.52		611	75
07/16/20					0.00	169.17	0.40					
07/17/20	6.35				6.35	175.52		0.04	2.27	8	913	450
07/18/20		1.36			1.36	176.88		0.28		56		
07/22/20					0.00	176.88	0.82					

District II – Cloud Base Aircraft, Seneca II (continued)

07/23/20			1.90		1.90	178.78						
07/24/20	3.91		1.05		4.96	183.74			1.69		679	225
07/29/20	0.92				0.92	184.66	0.54	0.14	0.18	28	72	
08/04/20	6.82				6.82	191.48	0.53		2.42		973	525
08/09/20	6.56				6.56	198.04	0.54	0.03	4.43	6	1,781	225
08/11/20			0.68		0.68	198.72						
08/17/20					0.00	198.72	0.73					
08/22/20					0.00	198.72	0.83					
08/27/20			0.12		0.12	198.84	0.51					
08/28/20			0.74		0.74	199.58						
					0.00	199.58						
TOTALS	**152.23**	**27.66**	**11.05**	**8.64**	**199.58**	**199.58**	**18.03**	**35.50**	**61.88**	**7,136**	**24,876**	**12,825**

TOTAL AgI RELEASED BY BASE AIRCR/ 44,836 grams

TOTAL FLIGHT HOURS CONTRACTED:	190.00
FLIGHT HOURS FLOWN TO DATE:	199.58
FLIGHT HOURS REMAINING :	-9.58
PERCENT OF FLIGHT HOURS USED:	105%

Appendix B

Piper Seneca II

PIPER SENECA II SPECIFICATIONS
4,570 lbs maximum gross weight
3,200 lbs typical empty weight
1,370 lbs typical useful load
Turbocharged, 200HP engines
Portable supplemental oxygen system
200 hp per engine at sea level
215 hp at 12,000 ft
225 mph max cruise speed
185 mph recommended cruise speed
70 mph stall in landing configuration
93-123 gallons usable fuel capacity
25,000 feet all engine service ceiling
14,000 feet single engine service ceiling
1,200 feet per minute all engine rate of climb
190 feet per minute single engine rate of climb
1,030 feet for takeoff over 50-ft obstruction
750 feet for takeoff ground roll
950 feet landing ground roll
28 ft. 07 in. length
9 ft. 11 in. height
38 ft. 11 in. wingspan

Cessna 340A

CESSNA 340A SPECIFICATIONS
6,290 lbs maximum gross weight
4,500 lbs typical empty weight
1,790 lbs typical useful load
Pressurized cabin
Turbocharged, intercooled 310HP engines
281 mph max cruise speed
263 mph recommended cruise speed
75 mph stall in landing configuration
183-203 gallons usable fuel capacity
29,800 feet all engine service ceiling
15,800 feet single engine service ceiling
1,650 feet per minute all engine rate of climb
315 feet per minute single engine rate of climb
2,175 feet for takeoff over 50-ft obstruction
1,615 feet for takeoff ground roll
1,850 feet land over 50-ft obstruction
770 feet landing ground roll
34 ft. 04 in. length
12 ft. 07 in. height
38 ft. 01 in. wingspan

King Air C90

KING AIR C90 SPECIFICATIONS
Full de-icing capabilities
Turboprop twin engine PT6A-21 engines
10,100 lbs gross weight
5,765 lbs typical empty weight
3,010 lbs typical useful load
550HP per engine
240 kts max cruise speed
384 gallons usable fuel capacity
30,000 feet all engine service ceiling
15,600 feet single engine service ceiling
2,137 feet per minute all engine rate of climb
626 feet per minute single engine rate of climb
3,100 feet for takeoff over 50-ft obstruction
2,250 feet for takeoff ground roll
1,730 feet land over 50-ft obstruction
800 feet landing ground roll
35 ft. 06 in. length
14 ft. 03 in. height
50 ft. 03 in. wingspan

Appendix C

NOAA FORM 17-4A (4-81) — U.S. DEPARTMENT OF COMMERCE — NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Form Approved OMB No. 0648-0025 Expires 01/31/2018

INTERIM ACTIVITY REPORTS AND FINAL REPORT

This report is required by Public Law 92-205; 85 Stat. 735; 145 U.S.C. 330b. Knowing and willful violation of any rule adopted under the authority of Section 2 of Public Law 92-205 shall subject the person violating such rule to a fine of not more than $10,000, upon conviction thereof.

NOAA FILE NUMBER: North Dakota Cloud Modification Project - District I

[ ] INTERIM REPORT [X] FINAL REPORT

Complete in accordance with instructions on reverse and forward one copy to:
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
1315 East-West Highway SSMC-3 Room 11554
Silver Spring, MD 20910

REPORTING PERIOD: FROM 06/01/2019 TO 09/08/2019

MONTH	(a) NUMBER OF MODIFICATION DAYS	(b) NUMBER OF MODIFICATION DAYS PER MAJOR PURPOSE				(c) HOURS OF APPARATUS OPERATION BY TYPE		(d) TYPE AND AMOUNT OF AGENT USED				
		INCREASE PRECIPITATION	ALLEVIATE HAIL	ALLEVIATE FOG	OTHER	AIRBORNE	GROUND	SILVER IODIDE	CARBON DIOXIDE	UREA	SODIUM CHLORIDE	OTHER
JANUARY												
FEBRUARY												
MARCH												
APRIL												
MAY												
JUNE	10	2	9			41		15,818				
JULY	9	4	8			27		7,833				
AUGUST	7	0	7			21		13,449				
SEPTEMBER	0	0	0			0		0				
OCTOBER												
NOVEMBER												
DECEMBER												
TOTAL	26	6	24	0	0	89	0	37,100	0	0	0	0
TOTALS FOR FINAL REPORT	26	6	24	0	0	89	0	37,100	0	0	0	0

DATE ON WHICH FINAL WEATHER MODIFICATION ACTIVITY OCCURRED *(For Final Report only.)* 08/26/2019

CERTIFICATION: I certify that all statements in this report on this weather modification project are complete and correct to the best of my knowledge and are made in good faith.

NAME OF REPORTING PERSON: Kelli Schroeder

AFFILIATION: ND Atmospheric Resource Board

SIGNATURE: Kelli Schroeder

STREET ADDRESS: 900 E Boulevard Ave Dept 770

OFFICIAL TITLE: Business Manager

CITY: Bismarck STATE: ND ZIP CODE: 58505

DATE: 10/1/19

NOAA FORM 17-4A (4-81) — U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION — Form Approved OMB No. 0648-0025 Expires 01/31/2018

INTERIM ACTIVITY REPORTS AND FINAL REPORT

This report is required by Public Law 92-205; 85 Stat. 735; 145 U.S.C. 330b. Knowing and willful violation of any rule adopted under the authority of Section 2 of Public Law 92-205 shall subject the person violating such rule to a fine of not more than $10,000, upon conviction thereof.

NOAA FILE NUMBER: North Dakota Cloud Modification Project - District II

[ ] INTERIM REPORT [X] FINAL REPORT

Complete in accordance with instructions on reverse and forward one copy to:
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
1315 East-West Highway SSMC-3 Room 11554
Silver Spring, MD 20910

REPORTING PERIOD: FROM 06/01/2019 TO 08/31/2019

MONTH	(a) NUMBER OF MODIFICATION DAYS	(b) NUMBER OF MODIFICATION DAYS PER MAJOR PURPOSE				(c) HOURS OF APPARATUS OPERATION BY TYPE		(d) TYPE AND AMOUNT OF AGENT USED				
		INCREASE PRECIPITATION	ALLEVIATE HAIL	ALLEVIATE FOG	OTHER	AIRBORNE	GROUND	SILVER IODIDE	CARBON DIOXIDE	UREA	SODIUM CHLORIDE	OTHER
JANUARY												
FEBRUARY												
MARCH												
APRIL												
MAY												
JUNE	10	5	8			62		27,920	788			
JULY	7	2	5			47		25,129	808			
AUGUST	13	0	13			104		59,460	1,538			
SEPTEMBER												
OCTOBER												
NOVEMBER												
DECEMBER												
TOTAL	30	7	26	0	0	213	0	112,509	3,134	0	0	0
TOTALS FOR FINAL REPORT	30	7	26	0	0	213	0	112,509	3,134	0	0	0

DATE ON WHICH FINAL WEATHER MODIFICATION ACTIVITY OCCURRED *(For Final Report only.)* 08/26/2019

CERTIFICATION: I certify that all statements in this report on this weather modification project are complete and correct to the best of my knowledge and are made in good faith.

NAME OF REPORTING PERSON: Kelli Schroeder

AFFILIATION: ND Atmospheric Resource Board

SIGNATURE: Kelli Schroeder

STREET ADDRESS: 900 E Boulevard Ave Dept 770

OFFICIAL TITLE: Business Manager

CITY: Bismarck | STATE: ND | ZIP CODE: 58505

DATE: 10/1/19